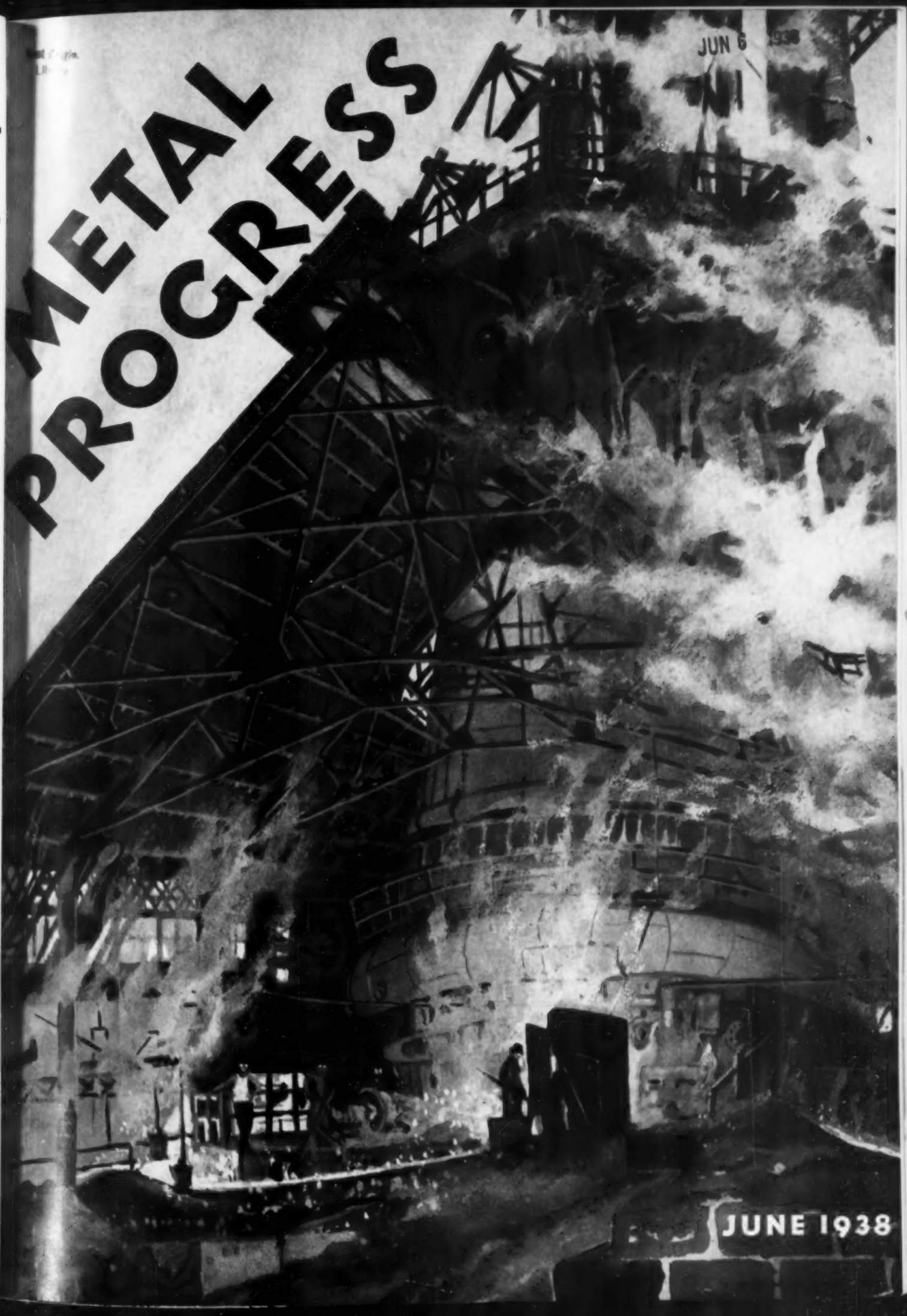
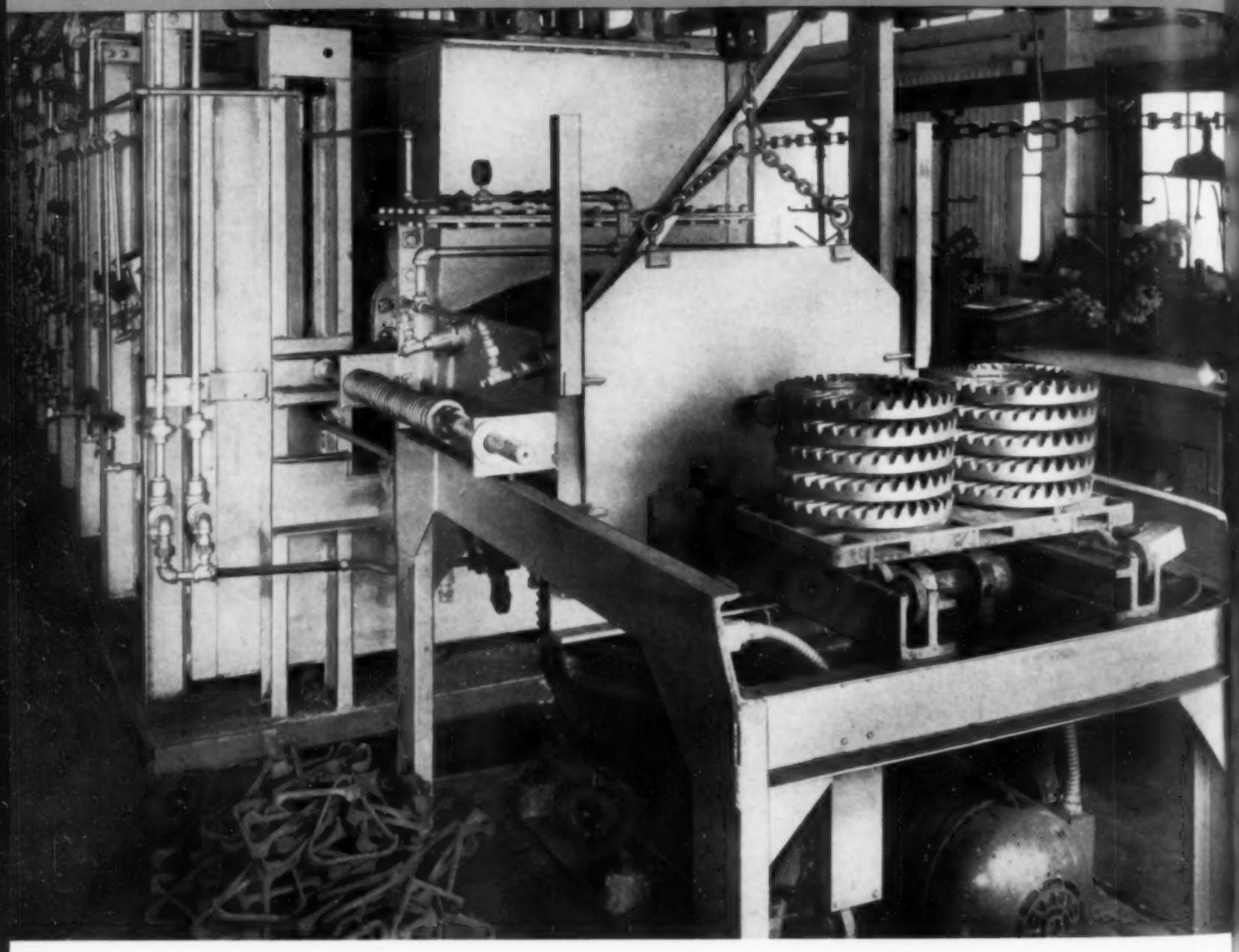
JUN 6

METAL PROGRESS



JUNE 1938

CUTTING COSTS IN HALF WITH EUTECTROL CARBURIZING



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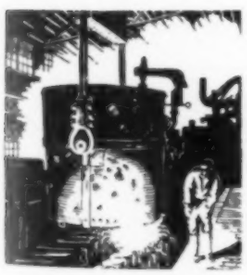

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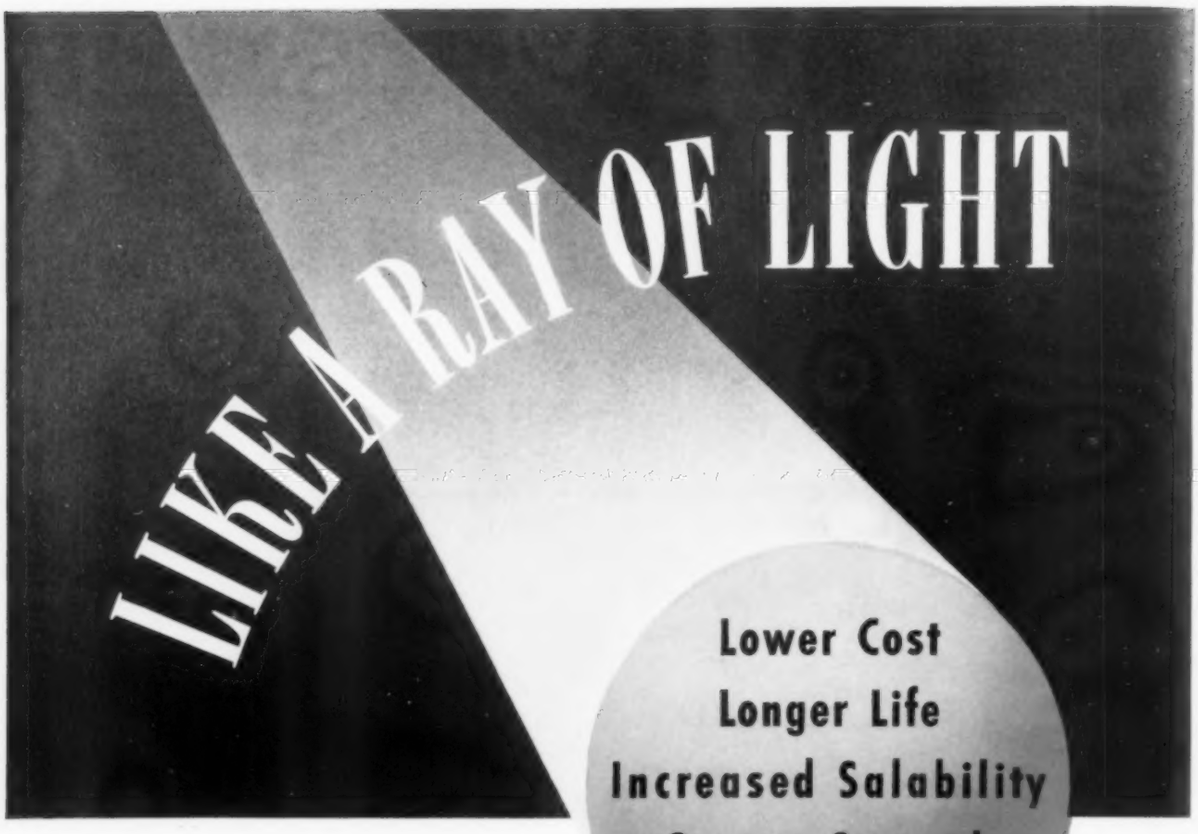

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Problems connected with steel manufacture from iron produced by an intermittently operated blast furnace, control of sulphur and oxygen in iron and steel, grain size of steel, and slab ingots for wide strip mills, occupy three-day discussion in Buffalo

Better Metal From Blast Furnaces and Openhearths

THE 21ST ANNUAL CONFERENCE of blast furnace and openhearth operators and metallurgists was held in April in Buffalo, N. Y., under the auspices of the American Institute of Mining and Metallurgical Engineers. For the most part the conference followed the question and answer plan which has been used in previous meetings. On subjects which were new to the majority of those present, short papers were read to stimulate discussion.

All of the topics presented during the three days were enthusiastically discussed, and it was only through the able guidance of the chairmen of the various sessions that the entire program was completed in the limited time available. Attended by over 400 blast furnace and steel plant operators from all parts of North America and from several European countries, it was interesting to note that in this period of low operations, when production costs are of great importance, no plans were suggested that would sacrifice quality for costs.

Pig Iron Improved by Soda Ash

An annual feature of these conferences has been the joint session of the openhearth and blast furnace groups, where the effect of blast furnace practices on openhearth operations and quality of steel was discussed.

Any period of low operations necessitates changes in blast furnace practice. In many plants the openhearth department is not able to handle the full production of a single blast furnace so that slow blowing or "fanning" has been necessary. The chief disadvantage of slow blowing lies in the low temperature of the iron produced; openhearth operators report that this results in foamy slags which increase the time of heats.

"Fanning," which is an intermittent operation of the blast furnace over short periods, is thought by some operators to be more satisfactory than slow blowing. They claim that the iron produced is at a higher temperature and that the furnace is more adaptable to the demand, as more iron can be produced on short notice if the openhearth shop needs it.

These practices, together with the use of large quantities of scrap in the blast furnace burden, were reported to have little effect on the quality of steel produced in the openhearth. The exception to this would be in the contamination of the pig iron by alloys in the scrap. Most blast furnace operators avoid this difficulty by a careful selection of the scrap to be charged. Although some of these practices result in increased costs of openhearth production, it was realized by all present that in the last analysis, over-all costs are the only costs of importance.

By Irving A. Oehler
Openhearth Metallurgist
Republic Steel Corp., Buffalo, N. Y.

An interesting discussion was held on the desulphurization of hot metal with soda ash. It was reported from Europe that ores high in sulphur are being smelted with no attempt to desulphurize in the blast furnace. The iron from the furnace is then treated with soda ash or a mixture of soda ash, fluorspar, and limestone. By this treatment, up to 70% of the sulphur can be removed from the metal.

In this country, high sulphur ores do not have to be used as yet, but it was reported that production costs can be reduced by operating a blast furnace on a leaner burden and desulphurizing in the ladle. It was pointed out that desulphurizing with soda ash helps to clean up the metal and also increases its temperature, a point that was looked upon with favor by the openhearth men present.

Steel Furnace Details

The opening session of the openhearth meeting was devoted mainly to plant equipment and construction. A number of new devices and new methods of construction were described.

Welded ladles are coming into widespread use. The increased size of heats tapped, together with the limitations of existing cranes, has created a demand for larger but lighter ladles. The new welded ladles, which are generally of the elliptical type, are 40% lighter than riveted ladles of the same capacity. After fabrication, the ladles are usually given a subcritical anneal for strain relief, although some now in use have not been heat treated. Welded ladles up to 165 gross tons capacity are being used successfully.

In some shops welded mold cars are being compared with the cast steel cars commonly used. The welded cars are more resistant to shock and lend themselves readily to alterations which may be necessitated by changes in mold or stool design.

Thermal insulation on the furnace sidewalls and roofs has been tried in a number of shops with varying results. In all cases it has resulted in a saving in fuel, but several operators reported that it causes a decrease in roof life, the cost of which more than offsets the fuel saving. On the other hand, other men reported an increase in roof life. It was suggested that the manner in which the roof brick were set may have a considerable influence on the life of insulated roofs.

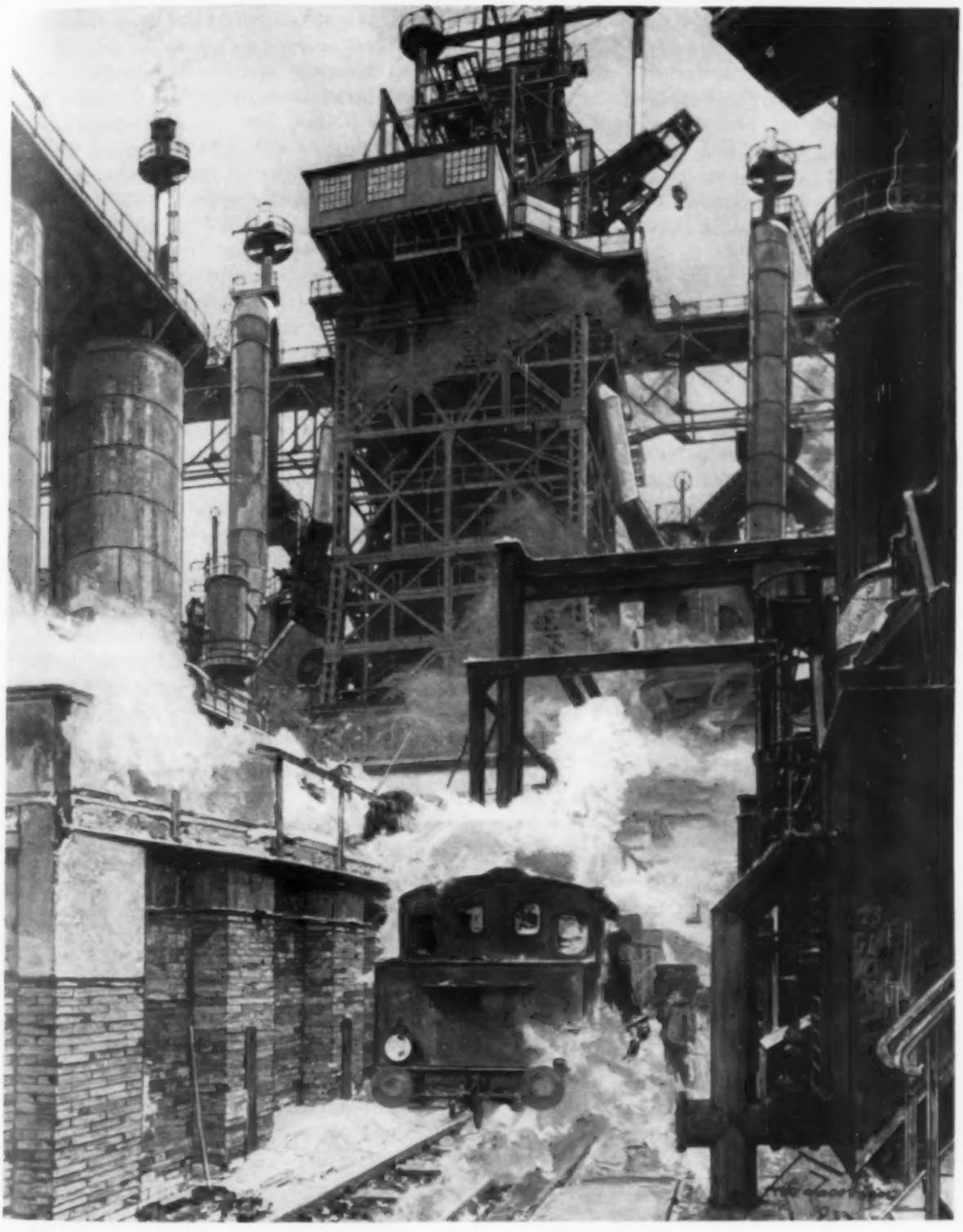
Automatic combustion control, together with automatic reversing mechanisms are coming into favor. The chief advantage of these devices, aside from more uniform control of brickwork temperatures, is that they give the furnace man more time to observe the working of the heat and thereby secure a closer control of the steel making process.

Quality of Rimming Steels

Properties of rimming steels were discussed in two short papers. It was found that the gases evolved during the rimming period consist largely of carbon monoxide. On a carbon steel containing 0.08 to 0.10% carbon about 90% of the evolved gases would be carbon monoxide, the balance being made up of about equal parts of carbon dioxide, hydrogen, and nitrogen. On a lower carbon steel the amount of carbon monoxide would be somewhat less with a corresponding increase in carbon dioxide, the total volume of gas being greater than from the higher carbon grade. The rate of gas evolution falls off quite rapidly as the time from pouring progresses, reaching zero when the ingot freezes over.

In one investigation the pressure of the evolved gases was measured at the same time samples were withdrawn for analysis. From these observations it was concluded that gases near the bottom of the ingot would be at a low pressure and would not be able to rise through the molten steel, due to the ferrostatic pressure, hence would exist as small subsurface blowholes in the solidified ingot. This butt condition is familiar to every steel maker, though the reason for its existence was not entirely clear.

The structure of rimmed ingots was also described in detail. The accepted technique for such study is to split several large ingots along the vertical axis, take a series of drillings in the primary or rim zone and in the central or core zone, and analyze these drillings for carbon, manganese, and sulphur, so that a complete picture of the distribution of these elements throughout the ingot can be obtained. It was found that the carbon content of the rim zone decreases slightly from the surface toward the core. At the junction of rim and core there is an abrupt increase in the carbon content. Proceeding along the vertical axis of the ingot from the butt end, the carbon remains quite constant for nearly three-quarters of the height; here the carbon increases, reaching a maximum



German Blast Furnaces Are Usually Enclosed in a Structural Steel Scaffold Which Supports the Top Works. Other items of contrasting practice may be seen by comparing the front cover of this issue (from a water color by Edward D. McDonald made at a Cleveland blast furnace) with the above half tone, reproduced from a mural by Fritz Jacobsen in the German exhibit at the 1937 Paris International Exposition, and reproduced by courtesy of the artist and Friedrich Krupp's Friedrich-Alfred Furnaces, Rheinhausen, Germany

at about 85% up from the butt. The distribution of sulphur throughout a rimmed ingot is similar to that of carbon. Manganese was found to be more uniformly distributed throughout the ingot, the changes from rim to core are less abrupt and there is not a great variation along the vertical axis.

The demand for longer and wider strip steel has necessitated the use of larger ingots for rimming steels of this grade. The trend in large slab ingots is toward ingots of a greater width-to-thickness ratio to prevent the necessity of cross rolling. Such large ingots make the problem of segregation more difficult. It was reported that the width-to-thickness ratio of slab ingots has little effect on strip surface provided the thickness is great enough to avoid butt splashes in pouring. Mold temperature, teeming rate, and time in molds were advanced as factors controlling the nature of the ingot surface. That small amounts of residual metals such as copper and tin are not important, was the belief of most operators.

Grain Size and Deoxidation

In answer to the question as to whether austenitic grain size is of increasing or of decreasing importance, it was reported that 75% of the killed steel is now made to a grain size specification. In addition, a normality specification is often included. Unfortunately, grain size control is not as simple as the control of chemical analysis.

For instance, grain size does not remain constant throughout all the ingots poured from one heat. Rather, there is a gradual coarsening of the grain in ingots poured toward the end. Use of ferromanganese in the furnace and a decrease in the time necessary to empty the ladle both decrease but do not eliminate such gradual grain enlargement in the ingots.

Most operators are using a combination of aluminum and ferrosilicon or calcium silicide as ladle deoxidizers to control grain size. If ferrotitanium is added with these other deoxidizers, "duplexing" is said to be reduced. ("Duplex" structure is one containing clusters of large grains in a generally fine grained metal.) The amount of deoxidizers used in most shops for a specified grade and grain size is governed by slag conditions.

Coarse grained steels, all agreed, are more difficult to make in the basic openhearth than are fine grained steels. Some operators believe that the type of scrap charged in the furnace is important in making this grain size.

Combined deoxidizers (alloys of three or more elements, two of which are generally silicon and aluminum) are coming into favor. Single deoxidizers give rise to cluster-like inclusions, while it has been found that the use of

Limitations of Existing Cranes Serving Enlarged Openhearths Create Problems in Handling the Molten Metal. Photo courtesy Youngstown Sheet and Tube Co.

combined deoxidizers reduces the tendency for the inclusions to cluster, or "string out."

One operator summarized the present stage of the art of grain control by saying, "Sometimes we get it and sometimes we don't, and we don't know why."

The majority of shops are using essentially the same method of controlling slags. The amount of limestone charged is determined by the quantity and the silicon content of the iron used. As the heat progresses and the slag begins to shape up, slag samples are withdrawn from the furnace and visually examined. Additions of burnt lime, spar, or other materials are governed by the appearance of the slag cakes. (For photographs of representative pancakes with various lime-silica ratios, see METAL PROGRESS, October 1937, page 436.)

It is the policy in many shops to duplicate, as nearly as possible, slag conditions on all heats of similar grades and then to make additions to the bath at definite times in the heat. In this way variables in the deoxidation practice are eliminated. Proper slag control has enabled some shops to control slag oxidations within 1% FeO.

The removal of sulphur and phosphorus from the steel bath is often a troublesome and time-consuming operation. It was reported that a rapid increase in the lime content of the slag is the most satisfactory way of overcoming sulphur trouble. High lime, together with a high percentage of iron oxide in the slag aids in the removal of phosphorus.

A new method of determining the oxygen content of molten steel was also briefly described: A small jug-like casting containing a spiral of aluminum wire and covered with a thin steel cap is immersed in the steel bath. The thin cap is rapidly melted, permitting the steel to flow into the jug where it is deoxidized. The walls of the jug chill the steel and the sample can then be removed from the bath without fear of oxidation from the slag or atmosphere. The sample is then drilled and the amount of oxygen in the steel is determined from an analysis for alumina. From the results obtained by this method, it was found that the oxygen content of the bath increases as the iron oxide in the slag increases, though not in direct proportion. As yet no evidence has been found that would indicate that the oxygen content of molten steel can be decreased by decreasing the iron oxide in the slag, though further work along this line is in progress.

Manufacture of Sponge Iron

By Charles G. Maier

Abstracted from Bulletin 396, U. S. Bureau of Mines

WHILE there are ample supplies of iron ore on the Pacific Coast, no coking coal is available. This, as well as the rather limited consumption of steel and iron, has prevented the erection of a blast furnace in that region. Availability of natural gas at 15¢ per M. cu.ft. warranted an investigation of the possibility of using it for direct reduction of iron in a small unit. Preliminary investigations in the laboratory at Berkeley, Cal., had shown the feasibility of the plan in a small unit producing 150 lb. per day, and semi-commercial apparatus with a capacity of about 1 ton per day was erected in 1934 by the Mountain Copper Co. at its Mococo plant to disclose the cost and produce sufficient sponge iron to test its utility and marketability. Raw material was refuse from a sulphuric acid plant—a very large pile of fine cinders, roasted and leached pyrite, containing 57% iron.

It was known from the Berkeley experiments that raw natural gas (methane and butane) was rather inert in the direct reduction of iron oxides at 900° C. (1650° F.), and that both ore and reduced sponge iron have a low thermal conductivity, so that the necessary heat for the endothermic reactions is transmitted slowly. Hence it was necessary to pre-form the gas into a more reactive state and heat it considerably before contacting with the ore.

Both of these objects were achieved by preheating about 40 volumes of air to 700° C. (1300° F.), mixing with 5.15 volumes of butane gas (measured at standard conditions) and passing the mixture through a hot catalyst (alundum granules impregnated with nickel). The effluent at 1000 to 1050° C. (1830 to 1920° F.) was passed directly to the reduction kiln, and its composition was quite constant: CO 21.6%, H_2 30.7%, N_2 44.0%, CO_2 0.8%, CH_4 0.7%, H_2O 2.0%.

To keep the effluent temperature within the above limits about 2 volumes of water vapor were added to the air before preheating. The temperature of the re-formed gas is a primary indication of satisfactory operation of the gas converter. Increase in temperature is compensated by increase of hydrocarbon or water, and decrease of temperature by slight increase of air. An occasional check on the chemical analysis of the converted gas is all that is further required to confirm the settings of

(Continued on page 640)

It is believed that no acute problems exist referable to inadequate cutting fluids, but in many instances a more expensive medium is used in one plant where a less expensive one is serving excellently in another. It would be desirable to determine the necessary amount of sulphur (or equivalent lard oil) in cutting fluids, and their respective functions

Cutting Fluids— Their Use Surveyed

A SURVEY of present practice in the use of cutting fluids recently was made by the Subcommittee on Cutting Fluids (of which Joseph Geschelin is chairman) of the Metals Handbook Committee on Machinability of Steel (O. W. Boston, chairman). It was thought that data thus collected would show trends and provide information which would help to revise the article on cutting fluids in the 1936 edition of the Handbook. Questionnaires covering 16 different types of cutting operations and 10 different metals were prepared so that each manufacturer could note, in the proper space, the type of cutting fluid used for roughing, semi-finishing, or finishing cuts. This questionnaire was sent to firms in the automotive and allied products industries and some others making miscellaneous machinery.

The following classification of cutting fluids was suggested as representing the types most generally used:

1. Emulsifiable oils
2. Sulphurized mineral oil
3. Sulphurized mineral and lard oil
4. Sulphurized lard and mineral oil
5. Mineral and lard oil
6. Mineral oil

A brief statement of the nature of each of these mediums will now be given.

Emulsifiable oils are those oils that form emulsions with water. They are made from mineral oils, mineral oil soaps, or fatty soaps, with water or alcohol added to hold the product in permanent suspension. Such suspended oils are mixed with various proportions of water to produce the emulsion, in which form they are used. Because of the great amount of water that can be used in the mixture, they are sometimes designated as "coolants," and are particularly applicable to those operations where the factor of heat removal from the tool is important and where the lubrication of the machine is not materially reduced by its double use in bearings and at the cutting tool.

Sulphurized mineral oils are used on more difficult work, or where the problem of tool and machine lubrication is involved. They are made by incorporating additional amounts of sulphur in the lubricating oil. (In evaluating the sulphur as an active reagent in cutting oils, only the *added* sulphur seems to be effective and not that which is native to the mineral oil.) Some plants use a sulphurized mineral oil with certain percentages of lard oil added, while others prefer a sulphurized lard oil to which is added a mineral oil. In any case, sulphur and lard oil, or the equivalent of the latter, must be considered as active additions to the mineral oil in the manufacture of a cutting fluid.

Compiled by
W. D. Huffman
Chevrolet-Forge, Detroit
for Handbook Committee

Mineral-lard oil is a compound of lard oil and mineral oil without added sulphur. Lard oil to the extent of 5, 10, or even 15% is commonly used.

Mineral oils without additions of fat or sulphur are considered aids in machining.

As remarked above, information on 16 different types of machines and operations was requested, and the returns will now be summarized. Practice will naturally vary with the type of metal or alloy being machined, so metals listed were low carbon, medium carbon, high carbon, and alloy steels, cast iron, malleable, brass, bearing material, aluminum alloys, and zinc. Each manufacturer was asked to indicate the class of oils most generally used in his plant on each machining operation and metal. A very favorable number of replies to this questionnaire were received.

Multiple Spindle Tapping: Sulphurized mineral oils, or sulphurized lard and mineral oils were most generally used for tapping steels; not one application of an emulsion for tapping steel was noted. Cast iron was tapped either dry or with an emulsion. Emulsions were most generally used for tapping malleable cast iron, and the non-ferrous metals were tapped dry or with emulsions.

Multiple Spindle Drilling: Emulsions were the almost unanimous choice for multiple spindle drilling of steel, iron, and non-ferrous metals. Drilling of zinc was the only exception, in which case preference was shown for dry cutting.

Drill Press: For use on the drill press a decided majority preferred emulsions. The second choice was the sulphurized mineral oil, although cast iron and the non-ferrous metals were, in some cases, drilled dry.

Automatic Lathe: The choice of a cutting fluid for automatic lathes seemed to be evenly divided between emulsions and sulphurized oils for steel. Non-ferrous alloys were machined with emulsions or dry. It was suggested that emulsions be used exclusively in this class of work where the lubrication of the machine is quite independent of the cutting fluid.

Turret Lathe (Chucking Machine): Emulsions were used on every type of material when being machined in chucking turret lathes. A few preferred the use of sulphurized oils. Particularly were sulphurized oils used on those machines where emulsions did not supply adequate lubrication to certain types of tools.

Automatic Screw Machines: Sulphurized oils, with or without lard, were used quite universally when machining steels in automatic screw machines. Non-ferrous metals were machined dry or with emulsions. Plain mineral oils are used frequently on non-ferrous metals in automatic screw machines if the work may be discolored by sulphurized oils and if the lubrication of the machine is of importance.

Gear Cutting: In cutting steel gears, sulphurized oils are most commonly used. Non-ferrous materials or non-magnetic materials are machined dry or with an emulsion. Some roughing operations on steel are reasonably successful when cooled with emulsions.

Milling: In plain milling, soluble oils are used on every type of metal. Sulphurized mineral oils, however, are next in preference. In milling with multiple cutters, emulsions are

High Speed Turning of Alloy Steel Gear Blank Requires Effective Cooling. Courtesy Haynes Stellite Co.

most generally used, but sulphurized mineral oils are second in choice. Non-ferrous metals are machined dry, with an emulsion, or with mineral-lard oil.

Broaching: Internal broaching of steel is most generally done with some type of sulphurized oil. Emulsions are used more generally on irons and the non-ferrous metals. Applications of emulsions in this branch of the art are increasing rapidly, and the near future may show a preponderance of emulsions over the sulphurized oils. In surface broaching of steel, the questionnaire showed about an equal division between the use of emulsions and sulphurized oils; emulsions or mineral-lard oils were preferred for non-ferrous metals.

Boring: In both horizontal and vertical boring, emulsions were most generally used on steel, while irons were machined dry or with an emulsion, and mineral-lard oil or emulsions on the non-ferrous metals.

Engine Lathe: Steels were machined most generally with the use of an emulsion or a mineral-lard oil. Irons and non-ferrous metals usually were machined dry or with an emulsion.

Threading Machines: A mineral oil or some type of sulphurized oil was the general preference for threading.

Grinding and Honing: Emulsions were the choice for every type of work in grinding. In honing the choice lay between emulsions and mixtures of mineral oil and kerosene.

A study of the results reveals a number of topics deserving future investigation. There are apparently no limitations as to the use of either emulsions or sulphurized oils, for in certain instances we find that either one is being used on the same type of operation. Although no definite information is available as to the conditions accompanying those operations, at least there can be no economic justification for using a sulphurized mineral oil where an emulsion will do. It seems that a familiarity with the machine and the material to be fabricated, combined with a knowledge of the functions and chemistry of the lubricant, should be reliable guides in the selection of cutting fluids. The conditions determining when a soluble oil or straight cutting oil can be used should be clearly defined and simplified if possible. This situation is not a simple one, but the two cutting fluids are so different in characteristics that it seems justifiable to assume that the factors governing the choice between the two can be lessened in number.

Another avenue for investigation is that regarding sulphur and lard oil additions. The amount of sulphur or equivalent that is needed should be determined definitely, and it is believed that technical means are now available for solving this problem. Do sulphur and lard oil perform the same functions, or does each contribute different essential characteristics? Many believe that lard oil or other saponifiable matter can be eliminated and that the straight sulphurized mineral oil will do all that the compounded oils can do. Again, some believe that additions of lard oil are essential to satisfactory machining, and they are so firmly convinced of its value that its incorporation in all the oils they purchase is insisted upon. Formerly it was indispensable because it was the medium through which sulphur could be introduced, but now that modern methods of manufacture have made it possible to combine the sulphur directly with the mineral oil, the problem can be observed from a different angle.

The kind of steel or type of cut does not seem to be of great importance in selecting the cutting oil. In most cases the same oil is used with mild steels as is used with high carbon and alloy steels. On roughing operations, a few companies are using emulsions. These are followed by sulphurized oils for the finishing cut. In general, the conclusion might be made that preference was determined by the oil rather than the metal or type of cut. Often a good oil was a general purpose oil.

It should also be remembered that the questionnaire did not in any way cover the very important problem of machinability of the metals being cut or the tools used. As a whole, the information herein must be viewed as a general picture of the types of cutting lubricants used on certain operations, rather than of any definite method for the selection of a material. There are probably many instances where applications are questionable, but it is believed that generally the practice is in keeping with present knowledge of the subject.

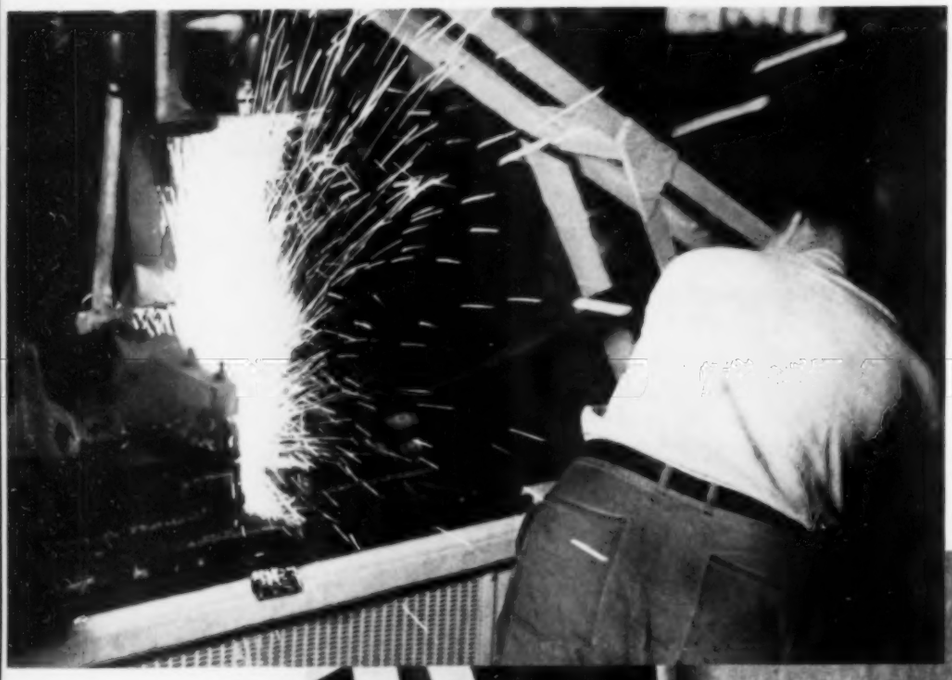
The fact remains that great amounts of metal are being satisfactorily fabricated, perhaps not as economically as possible, yet in such a manner that there is no urgent need to modify the application of cutting fluids. To repeat, there is no doubt that the subject is worthy of technical investigation, and with the definite knowledge thereby obtained, traditional methods should be supplanted by the scientific.

Order! Control! Precision! These mark the modern bearing plant . . . Far from being the generous mass of soft alloy cast within a bulky backing and scraped by hand to fit the shaft, the modern line bearing is a bimetal shell a few thousandths thick, held to tolerances measured by fractions of thousandths

Babbitt Bearings

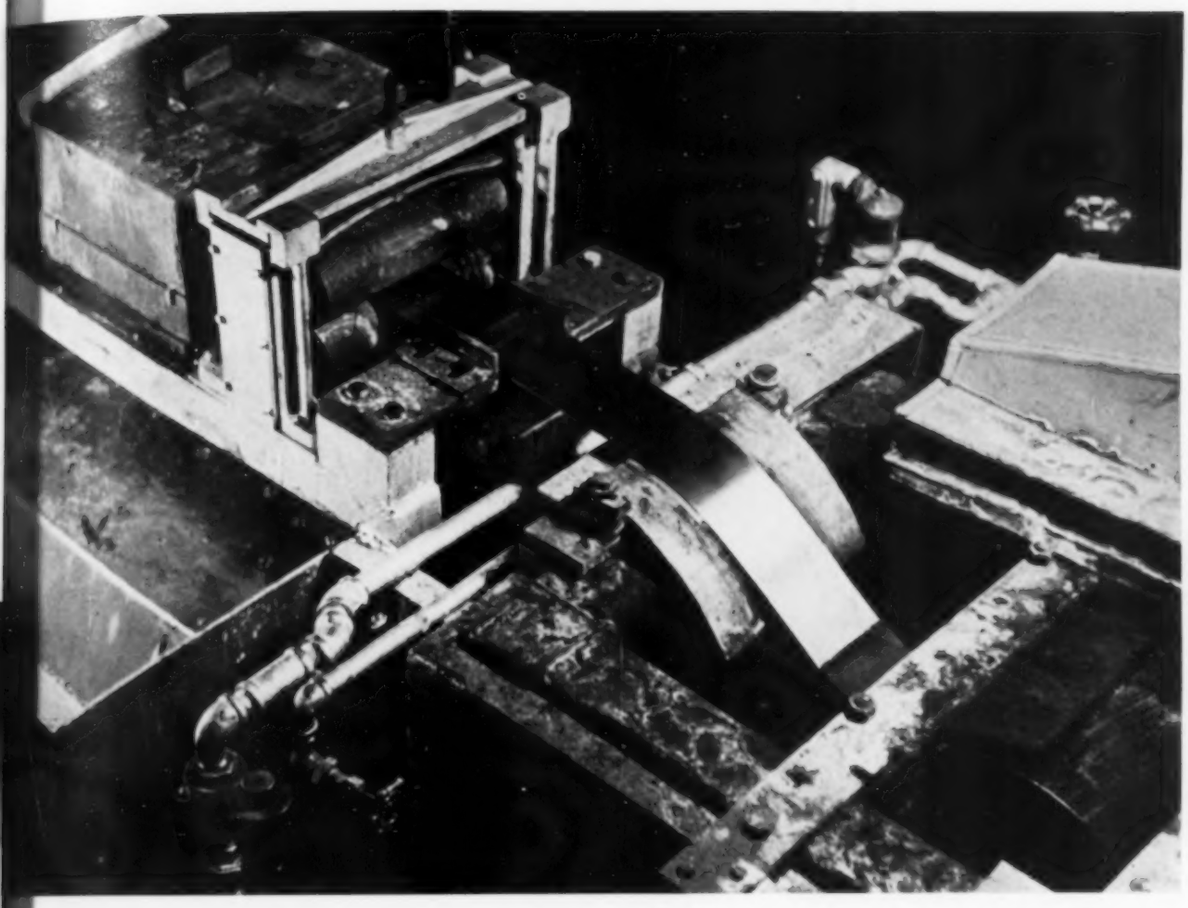
A photographic story
By Van Fisher
Made at
The Cleveland
Graphite Bronze Co.

COLD-ROLLED STRIP, meeting exacting specifications for finish, hardness, flatness, straightness and composition. It is fed continuously and automatically through cleaning and alloying machines, emerging as a bimetal. Cut and precisely finished, the steel forms an ideal stiff backing for the softer, more plastic bearing surface of babbitt metal.

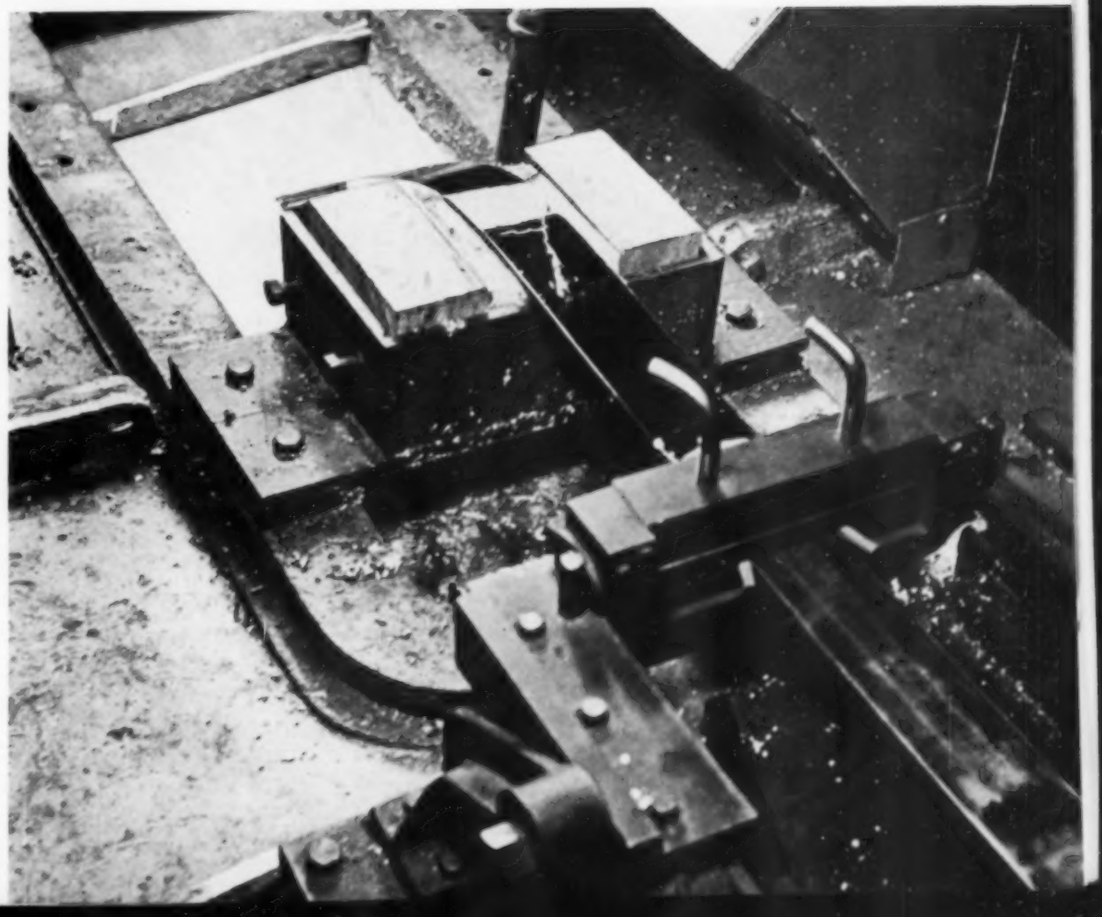


AN ELECTRIC BUTT WELD initiates the steel into the fabricating routine. As one coil approaches its end, the front of the next is joined to it and the joint is smoothed. Result is a continuous ribbon of steel passing without interruption steadily through the process.

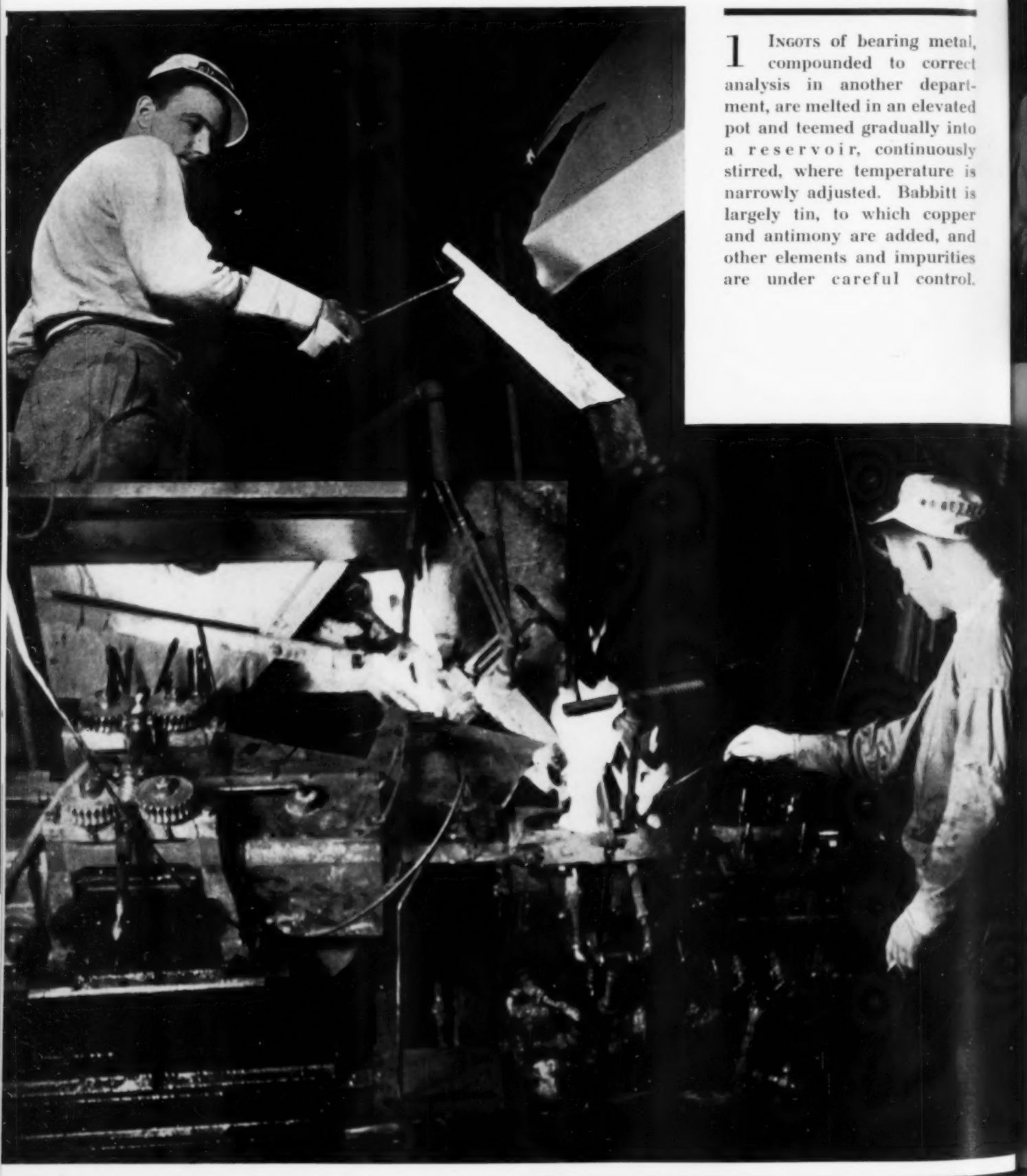
TO BE STRONGLY WELDED to another metal the surface must be physically and chemically clean. First, then, in series comes a hot, soapy bath, where grease is scrubbed off vigorously. (In many of these pictures, covers or guards have been removed prior to photographing.)



Up and out of the degreaser, the metal endures a blasting spray of clean water in the little box. Then through the wringer before dipping into the pickling tank where acid and electric current combine to remove all oxide or rust.



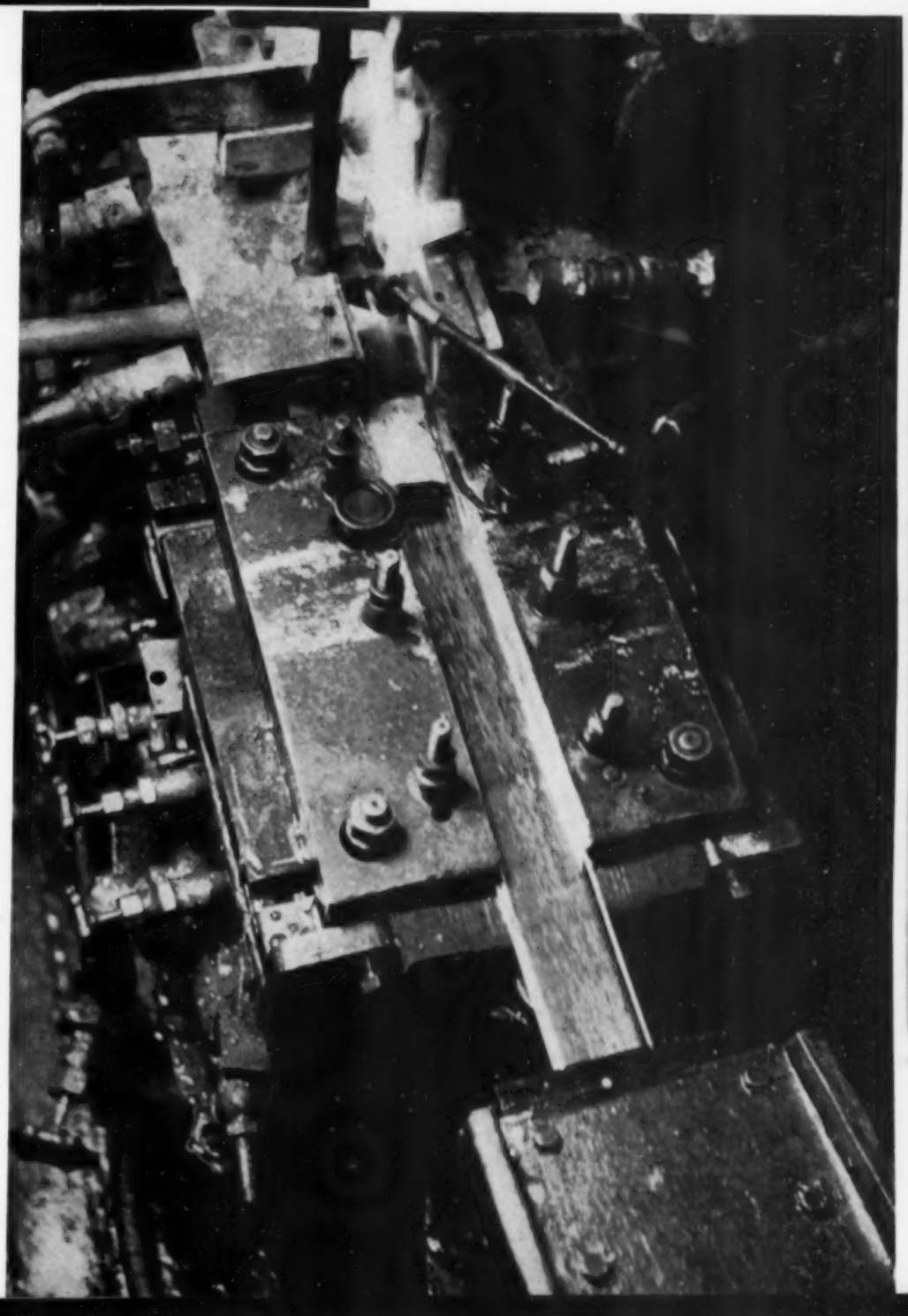
Again a high pressure washer and a wringer and the strip continues into a pot of molten tin, out of which it emerges with shining surface. Excess metal, still hot, is wiped off, leaving a film 0.00007 in. thick on the steel—almost microscopically thin yet thick enough for a very efficient bond between steel and babbitt.



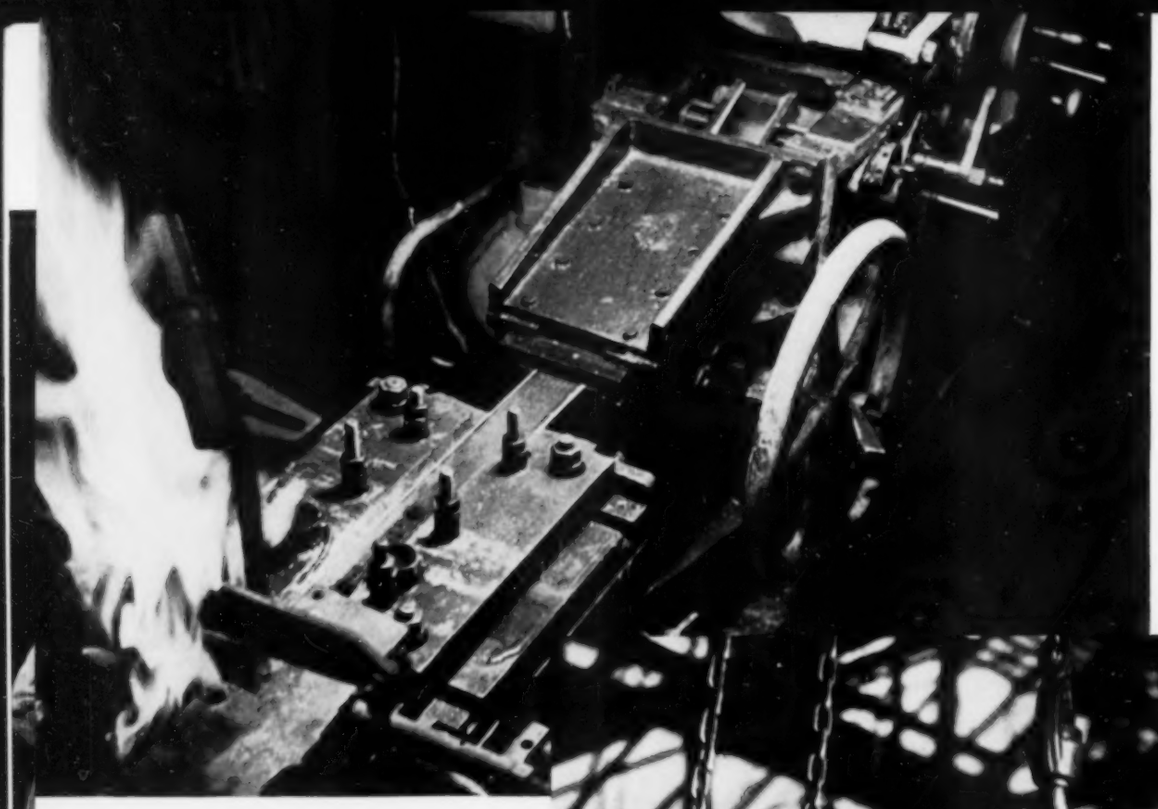
1 INGOTS of bearing metal, compounded to correct analysis in another department, are melted in an elevated pot and teemed gradually into a reservoir, continuously stirred, where temperature is narrowly adjusted. Babbitt is largely tin, to which copper and antimony are added, and other elements and impurities are under careful control.

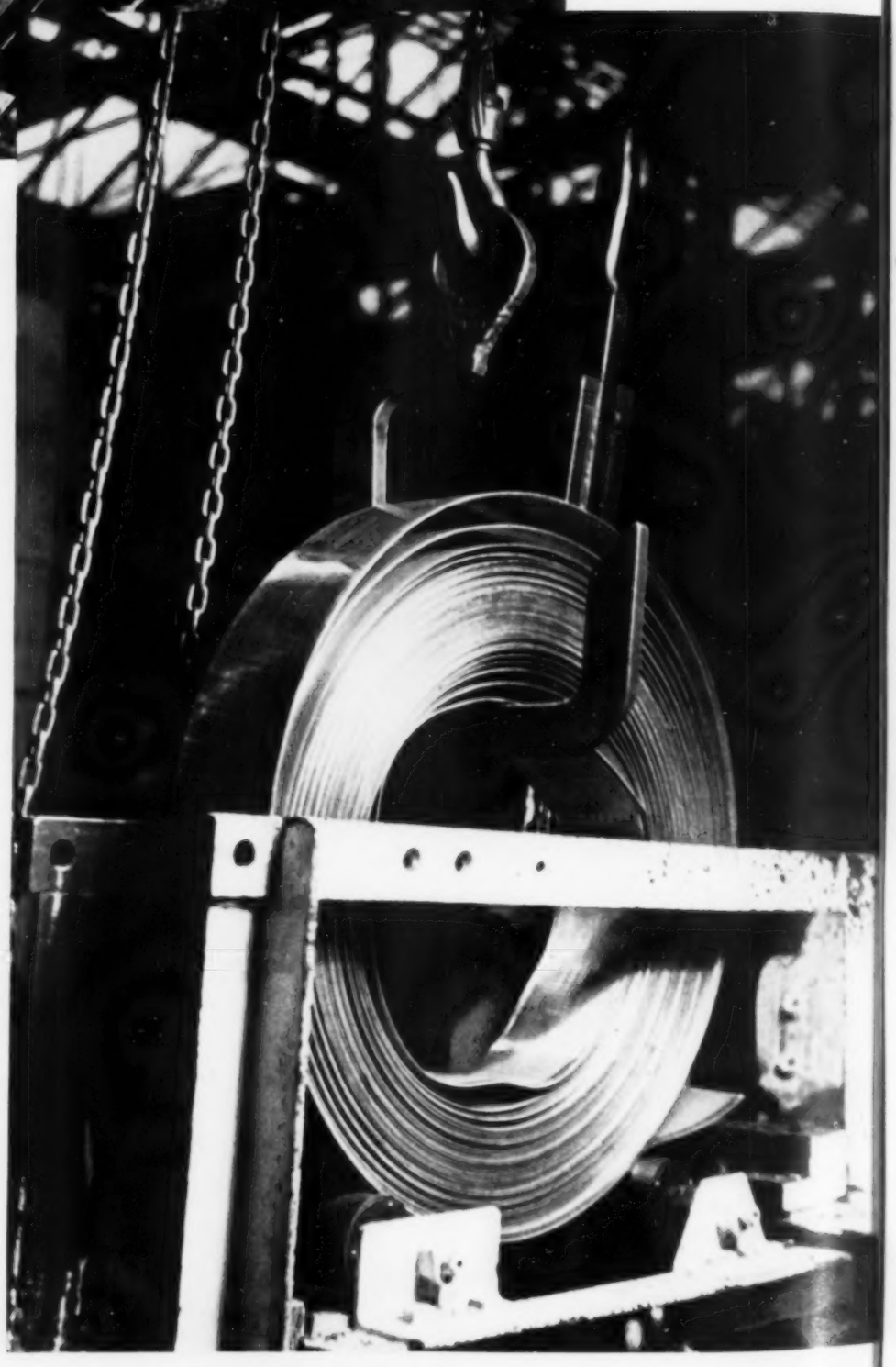
4 THE STATIONARY LOCATION and narrow transition from molten to solid, as the metal moves along, is evidence that every element of the process is under quite accurate and automatic control by banks of instruments shown dimly in the background. However, frequent independent checks are made with standardizing instruments.

EMERGING from the tin pot, the strip is carried rough a muffle with con-olled atmosphere to prevent idation of the film of liquid clinging to it. Through a se fitting slot it enters and rms the moving bottom of a uring box. This box receives steady stream of liquid bab-tt from the mixer above.



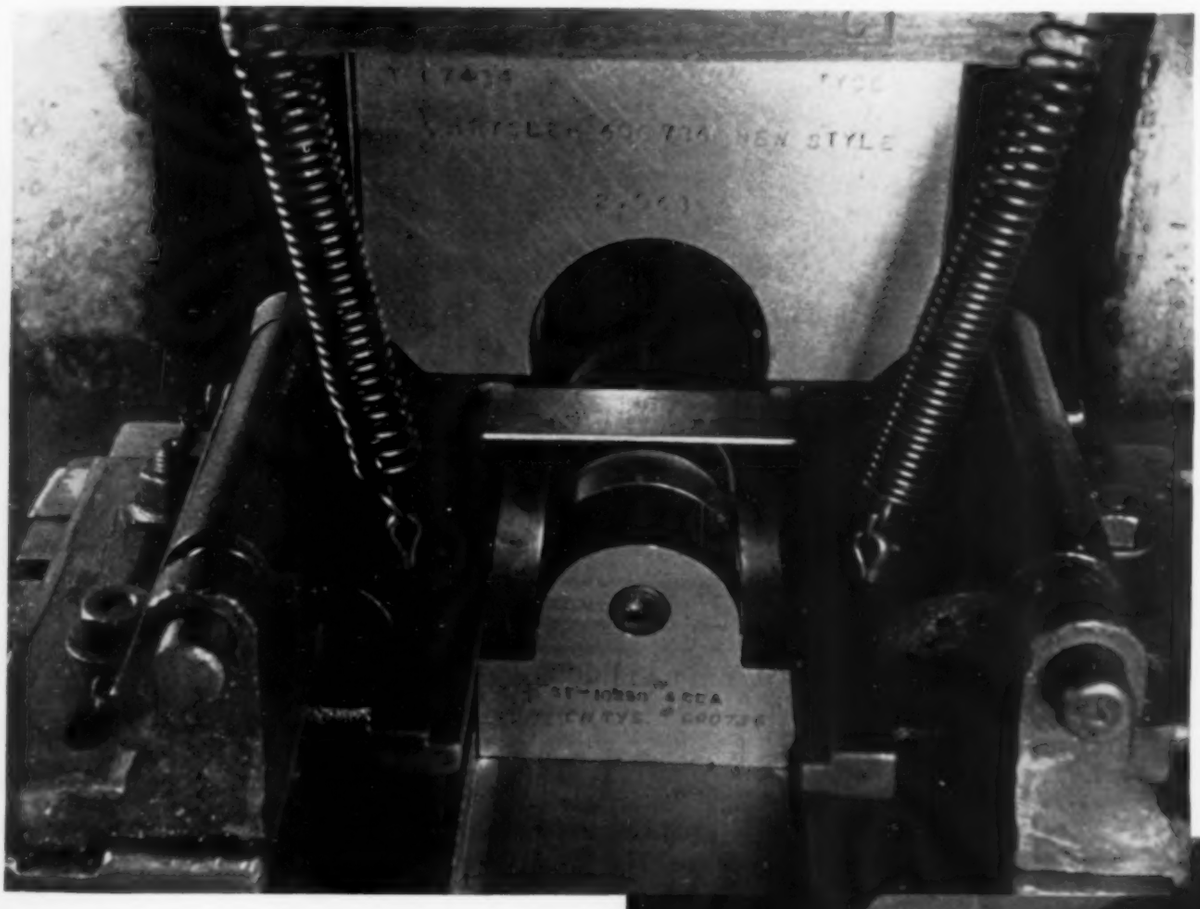
3 A SHEET of liquid babbitt flows forward. The bed of this stream is the moving strip. Its banks are guide blocks, right and left. Diaphanous oxide forms a cover. A clear mirror surface appears just momentarily when, from below, some water sprays quench the metal within an inch of travel — not instantaneously, but at a rate for the correct micro grain size.





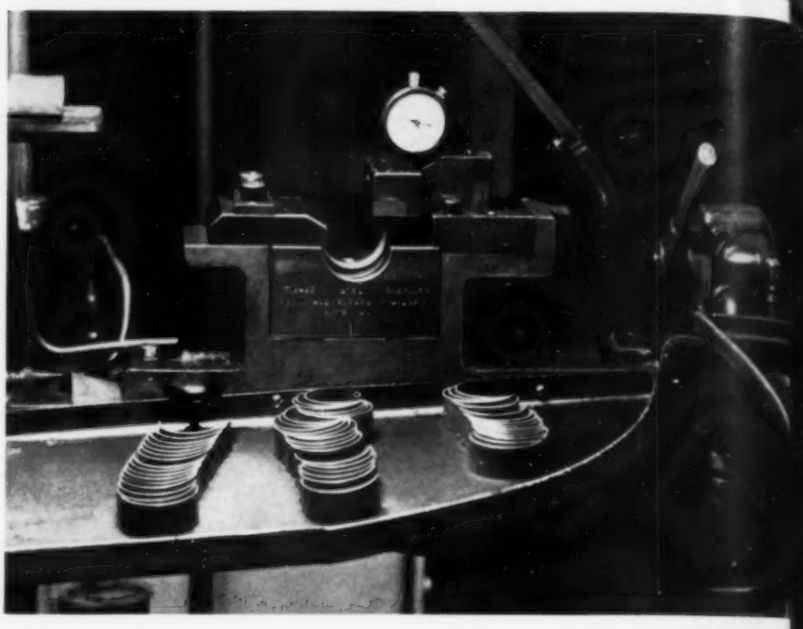
THE SAME REGION as shown in the last photograph on page 591 is viewed, above, from another angle. It looks ahead; the strip is passing into a milling machine — shown only partially in the background — where a series of line milling cutters remove the excess babbitt . . . Coming out at about 15 ft. per min. the strip is coiled, ready for subsequent forming and machining, but is now a bimetal, a steel base lightly tinned on one side, and on the other the required layer of babbitt, the latter often no thicker than 0.010 in.

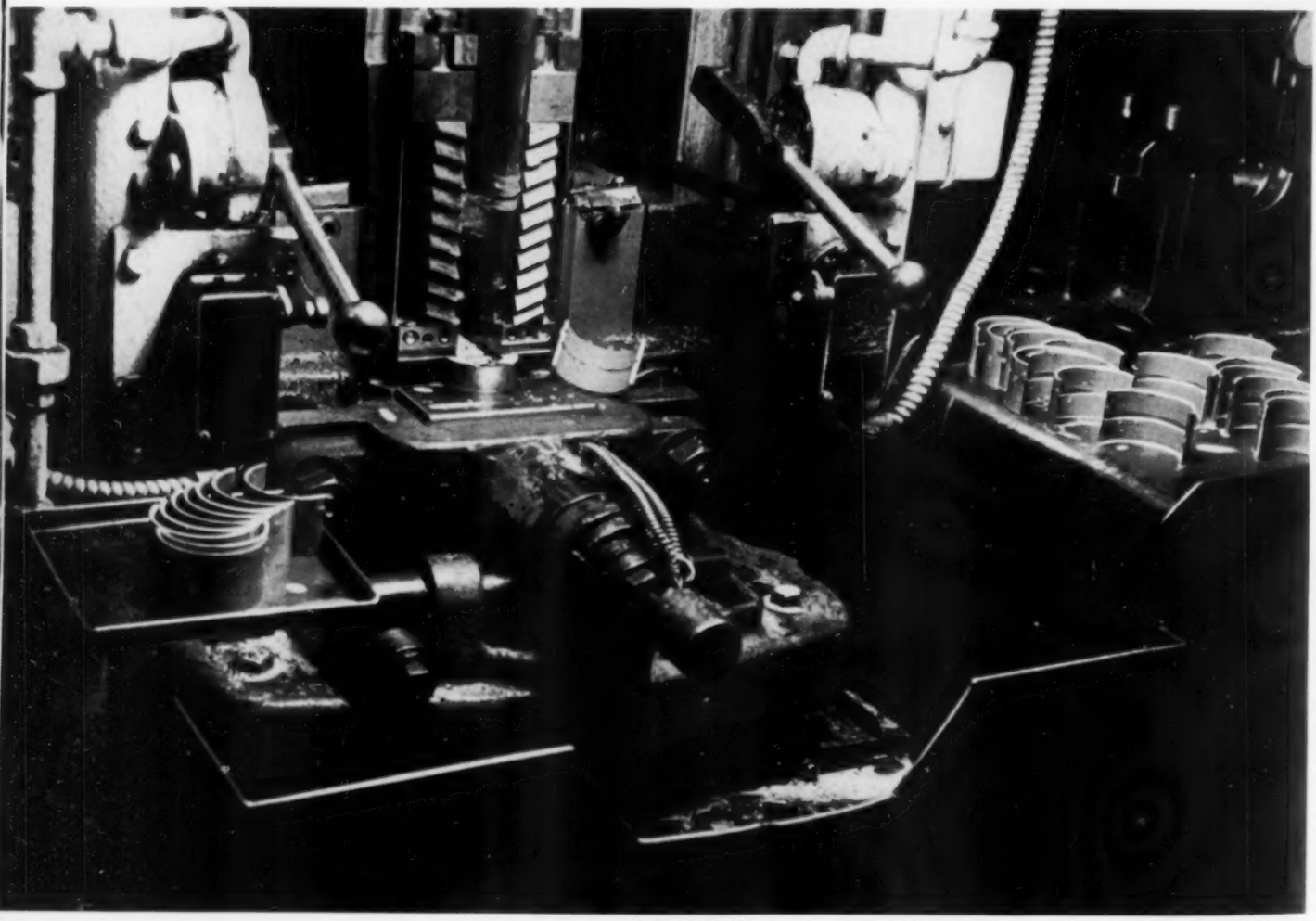
Machining and Inspection

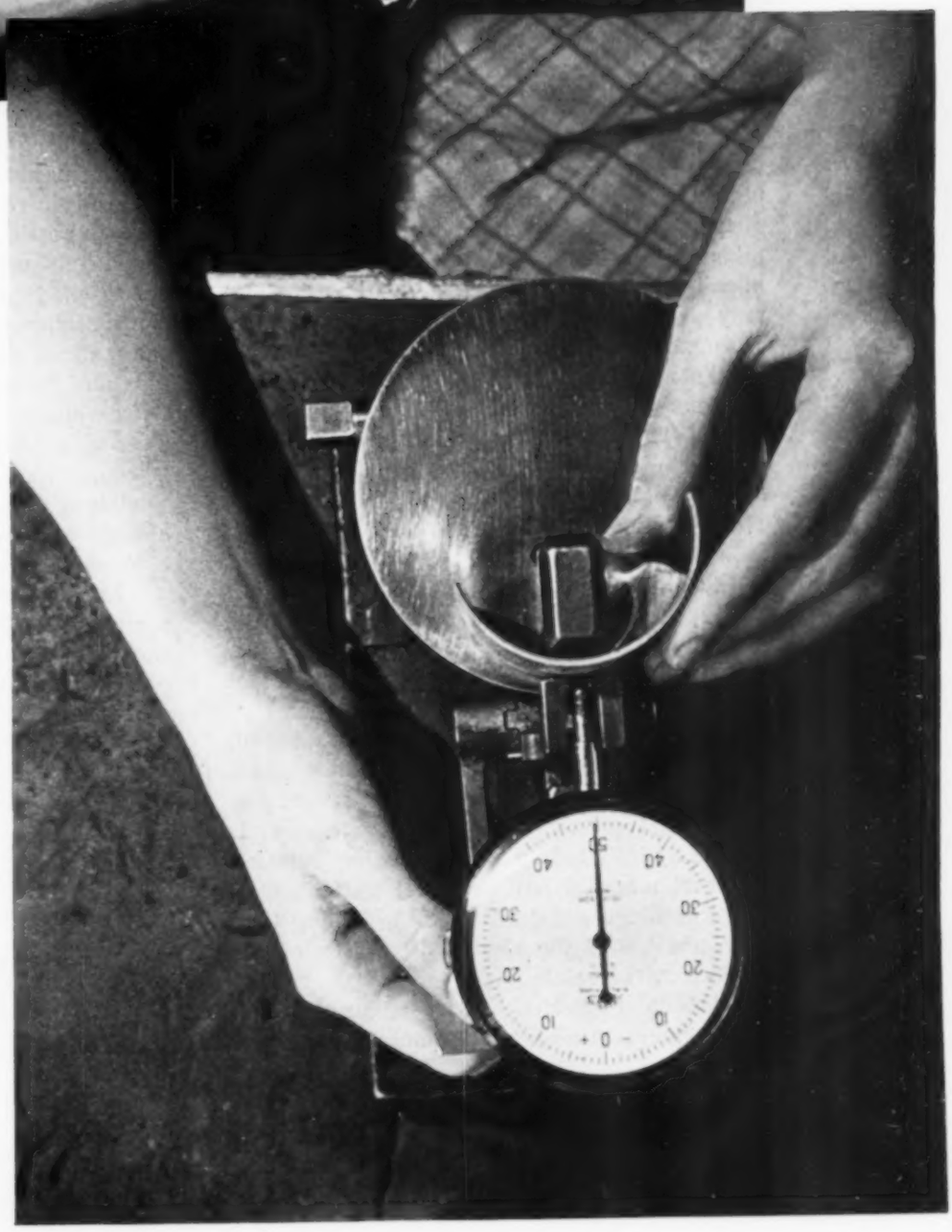


ONLY A FEW of the subsequent machining operations can be shown. First is a blanking press which cuts out neat rectangles and stacks them into a magazine for feeding the forming dies. As they drop into the waiting pans, we first see something that looks like a bearing. This forming operation is most important, as the accuracy with which the steel is curved determines the degree of accuracy that can be maintained in subsequent service.

INTERMEDIATE STEPS, not shown, include face chamfering to length, notching, drilling and grooving oil channels. Broaching the parting line starts the true finishing operations. Accuracy to 0.0002$\frac{5}{}$ in. (and 100% inspection, as shown) is necessary since this dimension controls the "crush fit" into its housing in the machine where it is to serve, and insures a perfect circle. Precision tools, checked in a constant temperature room against primary standards, are absolutely necessary, for if a broaching block were off size 0.0001 in., 40% of the production would probably fail to pass the required inspection.







FINALLY the hydraulic broach for inside surface is equally important. A jewel finish which no photograph can record is only part of the requirement. The inspector's yard stick is graduated in tenths of thousandths of an inch and tolerance is only 2½ divisions . . . Finally emerges a finished bearing, so uniform in size, so perfectly finished, that it can be placed in a gas engine as easily as a piece of paper in a typewriter.

Localized corrosion of 18-8 in chloride solutions has attracted more popular attention than its importance warrants. A four-hour test is described that correlates with experience in service. While higher polish reduces the tendency to pit, practical immunity is achieved by the alloy 18 Cr, 12 Ni, 3 Mo

Pit Corrosion of Stainless Steel

By Howard A. Smith
Stainless Development, Metallurgical Dept.,
Central Alloy District, Republic Steel Corp.,
Massillon, Ohio

ALL MANUFACTURERS of stainless steels as well as many fabricators have had complaints from customers who have been inconvenienced by tiny pinhole-like leaks in tanks, piping, digestors, steam jacketed kettles or evaporators. Such leaks are often the result of pit corrosion — that is, an intense corrosive attack within a restricted region which in time may penetrate the metallic sheet, leaving the surrounding metal practically untouched.

From accumulated experience, the causes for a majority of these failures have been established. The source of the difficulty can often be traced to conditions of service that do not directly involve the quality of the steel itself. Three of the major causes for pitting are as follows:

1. Pitting may be initiated by evaporation of drops of solution on the steel, concentrating the solution locally to a point where the steel is attacked in these restricted regions. Heat markedly accelerates this action.

2. Foreign inert material such as wax, sand, rubber, plastics or wood, in intimate contact with the steel in a solution will often start pits by "contact corrosion." (Contact corrosion is essentially initiated by minute crevices between the inert material and the steel which set up tiny solution concentration cells. Pitting then proceeds due to the electrolytic action of the short-circuited cell.)

3. Solid matter, either inert or potentially active, coming to rest and remaining in intimate contact with the steel during periods of evaporation, often at elevated temperatures, will cause pitting by a combination of the above.

For minimizing difficulties due to pit corrosion it devolves on the customer to cooperate as fully as possible with the steel manufacturer by furnishing operating procedure and service conditions in considerable detail so that intelligent recommendations can be made regarding fabrication, design, care of equipment, alloy type and finish. Such details of service conditions will also enable the steel manufacturer to offer suggestions as to the proper care of stainless equipment in service; too often the term "stainless" is interpreted to mean "proof against abuse," and even the normal cleaning operations are neglected.

Less frequently the surface condition, or composition, or physical constitution of the steel, is a major factor in the failure; sometimes combinations of these causes contribute to failure. It thus devolves on the steel manufacturer to maintain and to improve the quality and uniformity of his product, from the standpoint not only of its constitution and composition but also of its surface finish.

To aid in meeting such obligations there

has been developed a sensitive quantitative chemical method of determining the relative susceptibility to pit corrosion, and a rapid, reproducible method (electrochemical) of determining the stability of an alloy surface in various environments. Such properly conceived procedures of accelerated testing are much desired, for corrosion tests simulating service conditions on stainless steels often consume many months.

Ferric Chloride Solutions

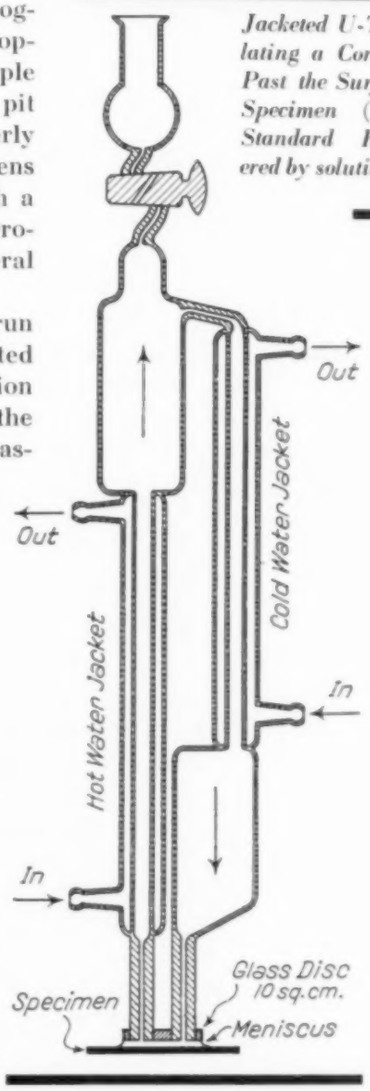
Ferric chloride solutions have been used for many years as etchants — that is, corroding agents for polished metals before microscopic examination, and for deep etching before visual study. Likewise the peculiar behavior of such solutions in initiating and propagating pit corrosion in stainless steels has been recognized since the early development of such alloys. Simple (but unreliable) tests for pit susceptibility were formerly made by immersing specimens in a beaker containing such a solution, and often led to erroneous conclusions for several reasons, namely:

1. Tests were usually run a long time in such a limited amount of corroding solution that the weight loss of the specimen was a partial measure of the amount of depletion of the solution, and therefore was not wholly a measure of any characteristic of the steel.

2. The corroding solution was not circulated over the surface of the steel. Corrosion products thus remained in contact with the metal and initiated a secondary attack, which could not be controlled.

3. Pitting would occur preferentially on the cut edges of the specimen, on points of contact with supports and at the air-solution-steel intersection. Pitting occurring at such places provides a cathodic protection to the remaining surfaces whose pitting characteristics are desired. Such behavior may thus cause the steel to appear better than it is in reality.

Jacketed U-Tube for Circulating a Corrosive Solution Past the Surface of a Steel Specimen (Below) at a Standard Rate. Area covered by solution is 10 sq.cm.



New Testing Procedure

For eliminating these undesirable features a method of testing was developed in a preliminary way about two years ago by the present author in some work done with the Corrosion Research Committee, Massachusetts Institute of Technology. The potential method was developed in the laboratory of the Alloy Steel Division of Republic Steel Corp.

The essential part is the device shown in the sketch. It is basically an inverted U-tube with water jackets on both legs of the "U." The lower ends of this U-tube fit into a circular glass disc with an area of 10 sq.cm. By applying suction through the stopcock on top, the corroding solution enters the U-tube openings at the bottom until the unit is filled. The stopcock is then closed, and the sample of steel to be tested raised to a loose contact below the glass disc; sufficient solution is first allowed to run on the sample so that it is covered, and a layer of solution 3 to 4 mm. deep remains between the sample and the glass disc.

Hot water is now circulated through the jacket on the left-hand side and cold water through the jacket on the right. Ensuing density (temperature) differences between the solution in the two sides then cause it to circulate in the direction of the arrows. Surface tension is sufficient to maintain the boundary of the circulating pool on the sample. Hot water at 95° F. and cold water at 68° F. (the standard testing temperatures) provide sufficient circulation to change the solution in the pool completely once every 15 sec. Sample and end of the tester are surrounded by a glass cylinder, not shown, to prevent evaporation of the solution.

So much for the equipment. As to the corroding solutions, the one extensively employed by us for stainless contains 10.8% $FeCl_3 \cdot 6H_2O$ in 0.05 normal HCl. Test period is four hours.

An accompanying table contains typical results obtained with the method above outlined. The weight losses and number of large pits are given for a 10-sq.cm. area. "Passivation" noted for one 18-8 sample is accomplished by a 15-min. immersion in 10% chromic acid at 170° F. The finish of the test pieces are the standard ones in regular steel production and are achieved as follows:

Finish No. 1, hot rolled, annealed, pickled.

Finish No. 4, standard polish. (This is done on a series of belt grinding machines, each using a canvas belt which has been glued and dressed with abrasive of proper size. No. 80 grit, dry, is usually the coarsest required, next No. 100 and finally No. 120, both using grease.)

Finish No. 6, standard polish followed with Tampico brush using pumice and lime in oil and kerosene. This finish is soft and satiny and has low reflectivity.

Finish No. 8, mirror finish, is No. 4 completed by at least two soft muslin wheels with manufactured grit No. 180 and No. 220 to No. 280 in grease, and finally buffed with green chromium oxide or white precipitated alumina.

A few points of interest in the above table should be especially noted.

1. Passivation (chemical finish by chromic acid) definitely increases the resistance of 18-8 to pitting.

2. The degree of resistance of an 18-8 increases directly with the degree of polishing (physical finish). A No. 8 mirror finish and a passivated No. 1 finish (hot rolled, annealed and pickled) are comparable.

3. The order of decreasing resistance to pitting of the various compositions is as follows:

A.I.S.I. Type 316; 18-12 plus 3% Mo
A.I.S.I. Type 302-B; 18-8 plus 2.5% Si
A.I.S.I. Type 302; 18-8
A.I.S.I. Type 430; 16% chromium-iron
A.I.S.I. Type 347; 18-10 plus columbium
A.I.S.I. Type 303; 18-8 plus selenium (free machining)
A.I.S.I. Type 321; 19-9 plus titanium

Relative Pit Susceptibility of Stainless Steel

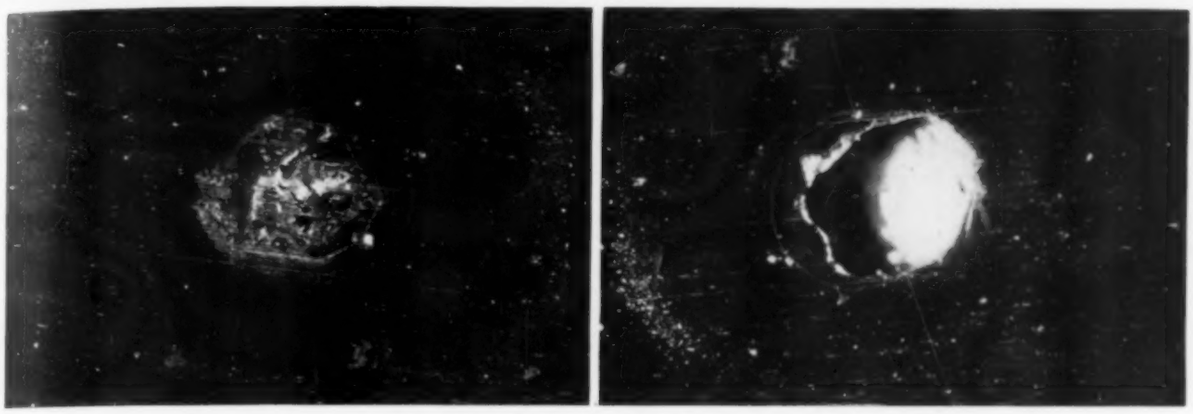
A.I.S.I. Type	Chemical Composition Limits					Finish	Weight Loss mg.	No. of Large Pits
	Carbon	Silicon	Chromium	Nickel	Other Elements			
302	0.08 to 0.20	0.75 max.	17.0 to 19.0	7.0 to 9.5	—	No. 1	30.2	20
					(Passivated) →	No. 1	2.7	2
						No. 4	25.1	13
						No. 6	12.6	5
						No. 8	5.5	2
302-B	0.08 to 0.20	2.0 to 3.0	17.0 to 19.0	7.0 to 9.5	—	No. 1	7.8	3
316	0.10 max.	0.75 max.	16.0 to 19.0	9.0 to 14.0	2.0 to 4.0 Mo	No. 1	0	0
303	0.08 to 0.20	0.75 max.	17.0 to 19.0	7.0 to 9.5	0.15 to 0.30 Se	No. 1	112.8	62
321	0.11 max.	0.75 max.	18.0 to 20.0	7.0 to 10.0	Ti = 6 x C	No. 1	249.9	184
347	0.15 max.	0.75 max.	17.0 to 19.0	8.0 to 12.0	Cb = 10 x C	No. 1	109.4	68
329	0.10 max.	0.50 max.	25.0 to 30.0	3.0 to 5.0	1.0 to 1.5 Mo	No. 1	116.3	0
430	0.12 max.	0.50 max.	14.0 to 18.0	—	—	No. 1	100.7	57
410	0.12 max.	0.50 max.	10.0 to 13.5	—	—	No. 1	302.5	0
Ingot Iron	—	—	—	—	—	Pickled	442.6	0

Note: The official limits for compositions of some A.I.S.I. Types have recently been altered somewhat.

4. American Iron and Steel Institute Type 329 deserves especial attention because while it loses about as much weight as Types 430, 347 or 303, there are no large pits. The type of attack is general, similar to that found on A.I.S.I. Type 410 (12% chromium steel) or on ingot iron. This characteristic is of distinct advantage in applications likely to give rise to pitting. This behavior of Type 329 is, we believe, due largely to its two-phase structure, shown in the photomicrograph on page 600.

Type Immune to Pitting

5. A.I.S.I. Type 316 (18-12 plus 3% Mo) deserves notice also as the solution used for testing may remain in contact with it for six months without action! In order to rate the molybdenum-bearing 18-8 to 20-12 compositions with each other a much more concentrated corroding solution is necessary.



Appearance (Magnified 25 Diameters) Under Unidirectional Dark Field Illumination, of an Undercut Pit in 18-8, No. 4 Surface Finish, and Same After Opening the Hole Up With a Needle

6. Ingot iron and 12% chromium steel suffer a general overall attack that is fairly rapid.

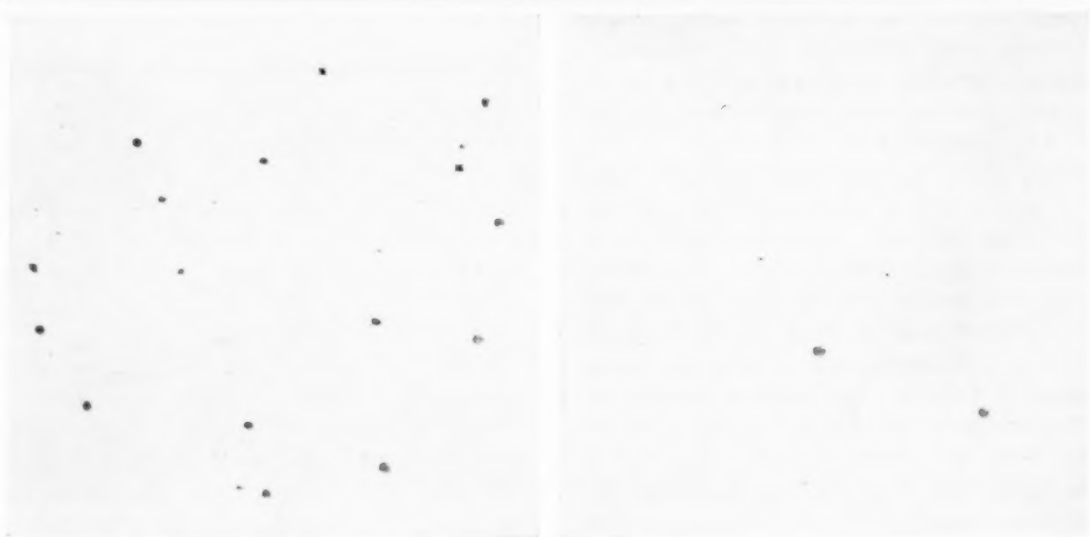
The appearance of a typical undercut corrosion pit on a No. 4 finish before and after it has been opened up by mechanical means is shown in the pair of micros just above. The other pair is of specimens, double size, of 18-8 and 18-8 plus silicon after the pits have been opened.

In order to be most useful, accelerated methods of corrosion testing should rate steels and surfaces in as nearly as possible the same order that service conditions rate them. The following qualitative statements may be made concerning this correlation:

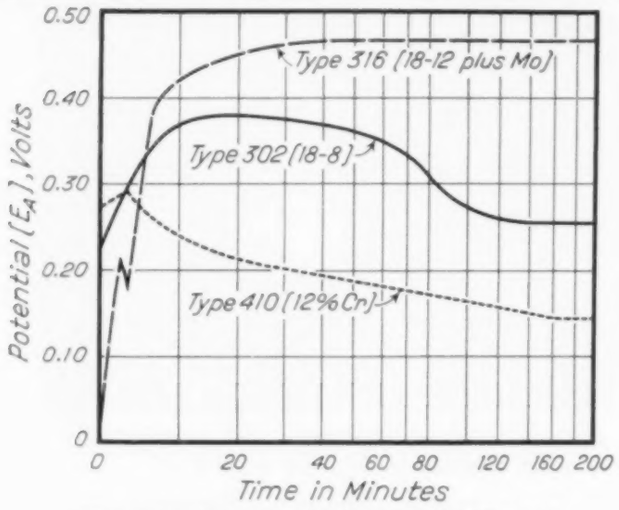
1. Ferric chloride solutions will corrode stainless intergranularly when precipitated carbides are present at grain boundaries (as will also occur if such steel is exposed to almost all corrosive solutions).

2. Considering the amount and kind of alloy additions, ferric chloride solutions rate stainless steels — using the equipment and methods described — in an order very close to that revealed by service records in most instances.

3. Ferric chloride solutions rate the *surfaces* on 18-8 stainless steels in the same order as revealed in service.



Pits Developed in 10-Sq.Cm. Surface, Double Size, After Probing With Needle. Left is 18% chromium, 8% nickel; right is same plus 2.5% silicon



Electrochemical Potential Varies With Time in Saturated Solution of Potassium Chloride. High potentials correspond to low corrosion rates

Surface Stability

In investigating the mechanism of formation of the passive film and its breakdown, and the final or stable trend in the corrosion of a stainless steel in a given solution, the variation of electrochemical potential with time is measured. Essential features of typical curves where time in minutes has been plotted against absolute volts are shown in the above diagram.

The method is due to R. M. Burns of Bell Telephone Laboratories and it has been described in *Journal of Applied Physics* for 1937, page 398. In brief it consists of immersing a sample of metal in a corroding solution and measuring continuously its potential by means of a standard mercurous chloride electrode and a recording potentiometer.

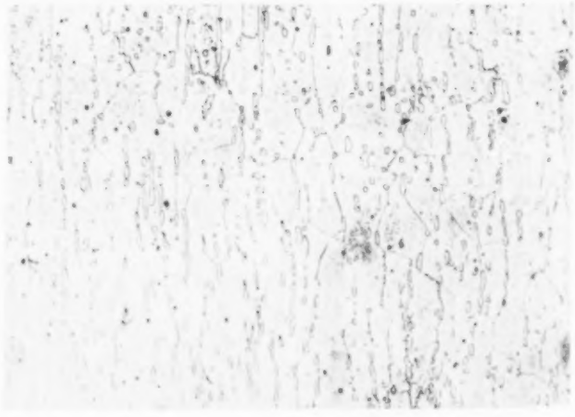
These curves as indicated are for Types 316, 302 and 410 in a saturated water solution of potassium chloride. In general it may be said that the higher the potential the less the corrosion tendency in this solution. Thus while Type 316 starts in at a low potential it rapidly becomes more resistant to corrosion due to the formation of a passive film. Types 302 and 410 also become more passive in this solution for a short time, but ultimately this passivity is broken down and their final tendency toward corrosion is considerably greater than that of Type 316.

Service behavior in chloride solutions follows closely these predictions.

It should be noted that while Type 316 starts with the highest corrosion tendency (lowest voltage) it very rapidly becomes passive; after one minute there is a temporary breakdown of the passive film which subsequently rebuilds to form the most resistant surface. Type 302 and 410 start at a definitely more noble potential than Type 316, but their final corrosion tendency is greater. These types (302 and 410) also tend to form passive films which are broken down in this solution and not re-formed into a more noble film for resisting corrosion.

For these three samples, at least, it seems that the less resistant the alloy is to corrosion the more noble will be the initial potential but the lower will be the final significant potential. From such curves one would expect Type 316 (18-12 plus Mo) to form a self-healing, corrosion resistant, passive film while an injury to the film on the other types might lead to pitting. This often is actually found to be true.

Considerable has been said in the last few years regarding pit corrosion in stainless steels. Its importance has been somewhat over-emphasized because so little was generally known about its causes and method of prevention. While some phases of pit propagation, some of the causes of initiation, and some methods of minimizing the occurrence of pitting are now well defined, it is here merely desired to present quantitative methods for further investigation of the fundamental causes for pit corrosion and for the practical control of fine stainless steels in production.



Islands of Austenite (and Evidence of Further Precipitation) in Ferrite Grains. Type 329 (27-4-1 Cr-Ni-Mo), water quenched from 2000° F. anneal. ×500

By means of general specifications, toolsteels may be purchased for definite duty rather than by brand name, from vendors whose materials have given the best records in the past . . . . Fracture of hardened disc is the most important inspection method.

Purchase and Inspection of Toolsteels

By Samuel C. Spalding
Metallurgical Engineer
The American Brass Co., Waterbury, Conn.

WHAT a disaster it is to have a tool, apparently perfectly designed and created, crack before it is finished — or it may start off confidently enough on its life's work only to fail after a very brief time! When this happens (and I presume we will have to admit it does happen) we become interested in the cause and means to prevent its repetition. This means an investigation by both the toolmaker and the producer of the toolsteel.

The thoroughness of the investigation on the user's part depends a good bit on his size and organization. The small concern usually has no one who can devote his time to this, so unless the cause is very apparent the steel is just thrown back on the producer with the claim that the steel is no good. The producer, with his better facilities and staff trained to the work, will, if the case is properly presented to him, make an honest effort to determine the cause.

The cause may be varied. The steel may contain some hidden flaw or defect which the toolmaker had no way of suspecting. The steel may be up to standard but, for the purpose intended, not the right type. The tool may contain thin sections where, if the steel is too deep hardening in character, the section will harden all the way through, weakening the tool; again, where it would be of advantage to harden to a considerable depth, the piece of steel used by the toolmaker may, unknown to him, have relatively shallow hardening characteristics.

The thought which logically comes to mind is, "Yes, this is doubtless true but how is the toolmaker to know? He ordered a piece of A.B.C. Steel Co. double extra special toolsteel, B temper, which, according to the catalog should harden with a fine grain at 1450° F. and contain all the properties of hardness and toughness that anyone could wish. Why, the steel representative told him so himself and what more could he do?"

Here is where the metallurgist, by setting up definite specifications for purchasing, inspection, selection and treatment of the steels required, can assist the toolroom, the shop using the tools and the steel company supplying the steel. Far from being fanciful, the foregoing illustrates a vital problem of industry, namely, the need of the consumer for more and better information from which to form his judgment of and select the right steel for the job, and the need of the producer for more and better information of what is required by and expected of the tools made from his steels after they are delivered to the consumer.

It is the metallurgist's job to bridge this gap. The metallurgist of the producer can help by determining in as much detail and as accurately as possible the properties of the steels he

Steel Specification No. 6

Type: Chrome vanadium alloy steel S.A.E. 6150.

Use: Where strength and toughness with moderate hardness are required; also for hot work where the operating temperature does not exceed 600 to 800° F.

Type Analysis: S.A.E. 6150.

Carbon	0.50 to 0.60%
Silicon	0.25%
Manganese	0.80%
Chromium	0.90%
Vanadium	0.18%

General: Can be purchased in hot rolled, cold drawn or centerless ground bars, also as sheets or special forgings. When purchased annealed, hardness should be between 160 and 180 Brinell. Can be purchased in heat treated condition to specified hardness or physical properties.

Heat Treatment: Heat to 1650 to 1700° F. Quench in oil. Draw 500 to 800° F.

Heat to 1550 to 1600° F. Quench in water. Draw 500 to 600° F.

Oil quench is usually recommended. For special purposes where cutting edges are desired or for maximum hardness, water quench is recommended.

Physical Properties:

Yield	Minimum Strength	Elong.	R.A.	Brinell	Treatment
205,000	230,000	10	40	444	1675° Oil 800°
170,000	190,000	13	50	380	1675° Oil 1000°
125,000	145,000	16	55	320	1675° Oil 1200°

makes. The function of the consumer's metallurgist is to study his applications of toolsteels in connection with these properties. Aside from the standard tools, such as twist drills, taps or cutters, which can be and usually are purchased from tool manufacturers, there are many calls for special tools and devices which must by their very nature be produced in the plant's own toolroom. The metallurgist can, and should, be an aid to the toolroom in the purchase of the toolsteels from which these tools are to be made.

It is for him to see that the required steels are purchased economically. "Economically" does not mean the cheapest steel or the most expensive steel. While it is an economic waste to use a more expensive steel than the job calls for, there are plenty of tool jobs where the price per pound of steel is so insignificant as to have no bearing on final tool cost.

The metallurgist should see to it, by proper inspection and testing, that the steels purchased are of required quality so the toolmaker and hardener can use them without fear of breakage, warpage or other troubles incident to the steel; he should advise with the engineers, tool designers and toolmakers in the selection of the proper steel for the job; he should supervise the heat treatment and, to a certain extent, the use of the tools.

In the past most manufacturers of toolsteel were very sparing in publishing specific information in their catalogs, which describe the steels in glowing but very general terms. (In passing, it should be said that some noteworthy exceptions to the above statement now exist.) But the ordinary purchaser of toolsteels will find a number of competing makers advertising various brands whose make-up and advised uses are generally the same. Each of these competing suppliers has representatives who call on the purchasing department, metallurgist, or toolroom foreman, and extol the virtues of his particular brand for the given purposes. In desperation the purchaser usually frees himself, either by tying up to one maker in whom he has confidence, or else keeps shopping around, trying the wares of this, that, and the other maker in a usually vain attempt to determine which best fills the bill.

Standardization is one solution.

Standardization of toolsteels has been decried by the makers as tending toward debasing them all to a common level lower than that of the branded steel. This, I believe, would not follow. Right here the metallurgist should step in, take the mystery out of the steel, and form the link between the various competing brands and the need of the toolroom for a steel of uniform quality. The plan for doing this which has been found quite successful by the American Brass Co. is essentially as follows:

Our metallurgical department first prepares a series of specification sheets which can be put

together as a loose-leaf book, and copies are placed in the purchasing department, engineering department, machine shop and toolroom. Three of these, selected at random, are reproduced. When steel is wanted the department in need can refer to this specification book and select, in many cases without further help, the type of steel best fitted for the job. The shop requisition is then made out for this selected steel by the numerical designation rather than a brand name, which requisition when received by the purchasing department is readily understandable. The purchasing department, in consultation with the metallurgist's records of inspection and performance, can then purchase from that supplier with the best and most consistent record — price and delivery being reasonable. In this way brand prejudices have been entirely eliminated in the shops of American Brass Co., steels being known by an arbitrary number.

Steel Specification No. 9

Type: Tungsten hot work steel.

Use: For maximum resistance to heat.

Type Analysis:

Carbon	0.50%	Chromium	3.50%
Silicon	0.25%	Tungsten	18.00%
Manganese	0.25%	Vanadium	1.00%

General: Can be purchased as hot rolled or hammered bars and in special forgings or sheets. When purchased annealed, the Brinell hardness should be between 210 to 240.

Heat Treatment: Preheat 1650° F., high heat 2300° F., quench air, draw 1350° to 1400° F. Should show hardness 260 to 300 Brinell. For special treatments for special properties, refer to table below.

Physical Properties:

Quench Temp. °F.		As Quenched	Drawing Temperature °F. 1000	1050	1100	1150	1200	1250	1300	1400
1900	Rockwell	48	51	50	50	48	47	41	38	27
	Brinell	—	502	512	502	463	460	405	356	275
2000	Rockwell	50	54	52	51	50	47	41	38	27
	Brinell	—	555	520	516	498	450	410	356	281
2100	Rockwell	55	57	54	53	53	49	44	40	29
	Brinell	—	591	560	555	528	488	444	382	293
2200	Rockwell	54	56	54	53	52	50	45	40	30
	Brinell	—	582	555	546	512	484	447	382	293
2300	Rockwell	55	57	55	53	52	50	45	41	30
	Brinell	—	600	569	550	516	498	444	385	295
2400	Rockwell	57	58	57	56	54	51	48	43	33
	Brinell	—	647	612	596	550	509	488	418	323

Having purchased the steel we must next devise a method of inspecting or checking the steel to see that the quality is up to the standard set by the specification. The principal methods to be used, other than measuring the dimensions, are the following five, the first three of which can be easily made and do not require research laboratory equipment and personnel: 1. Hardness, (Brinell or Rockwell); 2. Macroetch; 3. Hardening capacity; 4. Microstructure; and 5. Chemical analysis.

Testing for Hardness can be done by Brinell or Rockwell. It is a quick and simple means of checking the thoroughness of the mill's anneal and will weed out any piece which would cause machining difficulties in making up the tools.

Macroetching. For this test it is customary to saw a disc ¼ to ⅜ in. thick from the end of the bar to be tested. For details of the practice refer to the Metals Handbook, 1936 edition, page 573. Etched samples are then examined and graded as good, fair or rejectable. We try to class as "good" those samples that are unquestionably first

Steel Specification No. 3

Type: Medium carbon tool steel.

Use: Tools, dies, etc. Parts where high hardness and resistance to wear are required, together with some toughness.

Type Analysis:

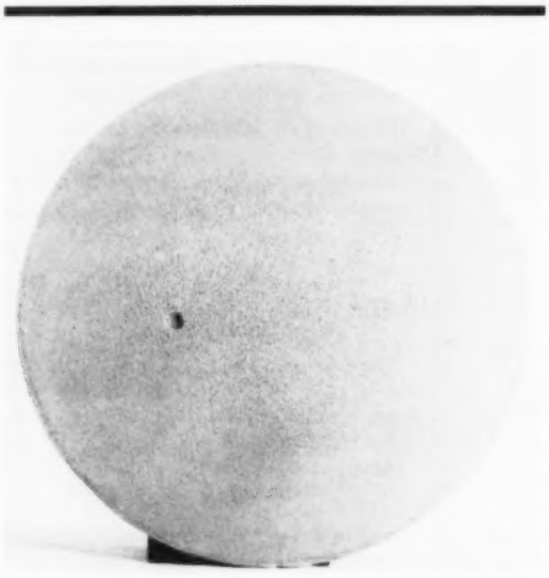
Carbon	1.00 to 1.15%
Silicon	0.25%
Manganese	0.30%

General: Can be purchased in hot rolled, cold drawn or centerless ground bars, also as sheets or special forgings. When purchased in the annealed condition, the Brinell hardness should be between 170 and 190.

Heat Treatment: Quench 1450° F., in water; draw 375° F.

class. In "fair" we place those which are not quite as good yet acceptable for the purpose, and doubtful discs which, though questionable of acceptance on their etched appearance, will be acceptable if satisfactory characteristics are revealed by the hardened fracture test. Those samples are rejected if they are distinctly unsuitable, and the steel stands rejected then and there, no further tests being made.

A word or two in regard to the macroetch test: First, be sure to use the standard routine as otherwise the results cannot be relied upon. Second, the interpretation of the test is difficult. Do not try to set up standards which are too arbitrary. Many things seen in the etch test have no bearing on the ultimate life of tools to be made from the steel. Arbitrary exclusion of all steel that does not come up to a fixed standard of etch will reject much satisfactory steel with a resultant hardship on the maker as well as the purchaser (in deferred delivery). Therefore, in all cases of doubt instead of using too high a hand, carry on other tests and be guided by the results so obtained.



Sample of Toolsteel, Rated as "Good" on Basis of Deep Etch Test; Unquestionably First Class

Hardened Fracture. As practically all tools must be hardened before they are ready for use, some knowledge of the hardening characteristics of the steel is of great value. In my mind, this test is the one of *most* importance when dealing with steel for tools. Many facts concerning the steel can be so revealed, such as hardenability, grain refinement, internal defects. How far we may wish to go depends on the individual plant requirements.

Credit is due to B. F. Shepherd, past president ASM, for methods whereby the "personality" of toolsteel may be evaluated by studying the variations in depth of hardening and in fracture grain size as the quenching temperature increases. (See, among other articles, METAL PROGRESS, February 1931.)

The sum and substance of the matter is that supposedly identical toolsteel from different makers and different lots from the same maker may have quite different hardening characteristics in regard to depth of penetration and fineness of the grain.

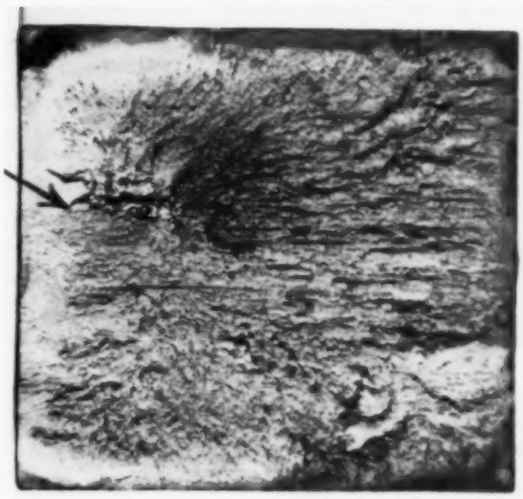
All sorts of refinements may be resorted to in classifying the hardenability characteristics. For large users where the steels are purchased in heat lots and duplicate standardized tools are produced, Shepherd's methods will be found very useful. In this article I am writing more for the moderate users, who, although in the aggregate buy considerable quantities of toolsteels in a year, buy it in small lots (often a bar or two at a time) and in a variety of sizes and grades. For them detailed hardenability tests would represent a considerable item of expense and be hardly justifiable. I will outline a simple, inexpensive method of testing which will give much information concerning the general hardenability and characteristics of the steel. After all, for the ordinary toolroom, this is desired: Toolsteels that will harden over a reasonable quenching range with a fine grain and to a moderate depth and free from objectionable internal defects.

Harden the Etched Disc

In following out our scheme of inspection we had already taken a ¼ to ⅜-in. disc from the end of the bar and etched it. This same disc can be used for the hardening test. Some will probably object to hardening a disc that has been previously etched but many checks of discs from the same bars, etched and not etched, have indicated that the effect of the etch is *nil* insofar as the characteristics of the hardened fracture is concerned for inspection purposes.

We take then the etched disc from the end of the bar, heat it to the highest hardening tem-

perature of the range recommended by the maker and quench in brine, water or oil as the case demands. It is desirable to use the top of the recommended hardening range as some steels are very sensitive to temperature; although they will harden well at a low temperature, they coarsen rapidly as the hardening temperature is raised. This may possibly for some things be desirable, but at least we should know we have this type of steel before we make it up into tools and this test will show it up.



Internal Defects Like This Should Be Caught at the Steel Mill; Fracture of Hardened Discs Are Better to Show Hardenability and Grain Size

In hardening discs of this kind, great care must be taken to standardize the hardening conditions in order to be able to interpret and compare the results. Especially, the quenching temperatures for the different steels under test must, therefore, be carefully set and adhered to and great care must be taken to get a uniform quench.

A good fixture for quenching may be made of pipe fittings and $\frac{1}{16}$-in. wire mesh. Flanged fittings for 3-in. pipe are covered by the mesh and bolted together, face to face, but with separators between about ½ in. thick. Pipe reducers leading back to a breeches fitting in a 1-in. line deliver coolant to each flange, and thus produce opposing sprays. A little chute is also built of the mesh so the hot disc to be quenched is delivered safely and promptly to the open space between flanges where it gets the full force of the cooling stream.

After hardening the discs are examined for surface checks and then broken across the center. This reveals whether we have a deep or a shallow hardening steel. The fineness of the grain also indicates whether our steel is very sensitive to heat or has a good margin for ordinary handling. With practice in examining the grain we can often tell from its appearance whether the steel has been mistreated in the forging or annealing at the mill. Lastly, any internal defects or weaknesses are plainly indicated.

Microstructure and Chemistry. The last two tests listed at the outset, namely microscopic examination and chemical analysis, are valuable but should be used more as occasional checks or means to investigate something

(Continued on page 624)

Sample at Left Would Be Classed by Mr. Spalding as "Fair," and Accepted or Rejected According to Results of Other Tests and if Axial Porosity Would Not Interfere With Intended Use. Other two samples are definitely "rejectable" on basis of deep etch. (Courtesy Frank R. Palmer)

Corrosion and wear are the big enemies of oil transporting equipment, and are being combated with special metals and alloys. Welding, while of greatest importance, still contains some unsolved problems worthy of metallurgical attention

Machinery for Moving Crude Petroleum

The first successful pipe line for transporting oil was built in 1865 and consisted of five miles of 2-in. wrought iron pipe. Growth of pipe line systems was steady from that time onward, but only during the past 25 years has this assumed tremendous proportions. The art of welding the pipe into a line of any length, first successfully accomplished in 1919, presaged the rapid development to a point where more than 280,000 miles of pipe, buried in the ground, are providing a safe and continuous flow of petroleum from oil fields to refineries and consumers.

The largest single item carried on the books of a pipe line company is the line pipe. All of it has been made by one of four general processes — butt weld, lap weld, electric weld and seamless. It will be unnecessary to describe their manufacturing processes; however some remarks on their comparative utility, as viewed by the present writer, will be in order.

Generally speaking, butt welded pipe is no longer used for high pressure pipe line work, even in small diameters, due to the inherent difficulty of obtaining uniformly a 100% joint. The surges and shocks encountered are such as to make this form of pipe construction unreliable.

Some of these difficulties are also inherent in lap welded pipe due to gas pockets, scale and inclusions, although, because of the greater contact area, the uniformity of the pipe is better.

Electric welded pipe starts as flat strip and considerable cold work is done on it in the forming operations. This, together with the ability to use a higher carbon steel than is readily weldable in the older processes, gives pipe of a higher ultimate strength. Consequently higher working pressures can be carried, or a lighter wall thickness installed. Here again, however, we find that the joint is the weak point, for although the mills thoroughly test each joint, it is possible for leaks to develop because of rough handling between the mill and destination. Inclusions or gas pockets, forming undetected pinholes at time of test, may show up after the line is in operation.

Seamless pipe, due to its method of manufacture, will possess none of the brittleness ascribable to cold work. It has a fine and uniform grain structure, and is slightly stronger than a fully annealed tube made of the same steel. It is generally considered a superior and more uniform product.

It will usually be found that price differentials ruling for the standard classifications are counterbalanced by increased weights due to lower allowable unit stresses. The choice of pipe to be used in a particular line therefore becomes largely one of engineering economics based on service life required, class of service, availability, freight, and handling costs.

In view of the almost universal use of welding for field joints, all companies incorporate in their specifications some definite welding practices and require qualified welders. However, the weld itself changes the microstructure and physical characteristics of the pipe metal adjacent to the weld. The

By Lewis F. Scherer
Assistant Chief Engineer
The Texas Pipe Line Co.
Houston, Texas

From the Western Metal Congress paper: "Materials Used in Pipe Line Construction and Operation."

welders themselves, being human, make some welds which are now undetectably poor. Until means is developed which will permit detecting these poor welds by some simple inspection, the welded joint will continue to be the weak point in the line. We, in the pipe line business, are particularly interested in the development of welding practice as applied to our problems and would welcome some means which would assure us of a 100% weld, not only in the pipe as now used, but in pipe of a higher carbon content. A means of readily determining a poor weld by some simple and economical test would also find ready acclaim.

In all types of fusion welding, a non-uniform structural condition is induced near the weld. Physical characteristics of increased strength, hardness and embrittlement may be obtained in a refined grain structure, but its incorporation in a pipe wall of normal grain structure must result in a concentration of applied stresses and since these are confined within the narrow limits adjacent to the weld, they are detrimental to the pipe. Coupons, taken from butt welded joints and tested for tensile strength and elongation, substantiate the above remarks in a general way.

Most of the pipe used is of a carbon content of 0.30% or less. This is largely due to the thermal effects of welding which would tend to nullify the admitted advantages to be received through the use of a higher carbon steel. This thermal effect of course becomes much more pronounced as the carbon content increases; tests of coupons taken across the butt welds of high carbon pipe have shown that failure occurs almost invariably at a value lower than that of the original structure.

Field Joints and Fittings

Screw type elbows, tees, branches — all manner of fittings — are of course replaced by welded fittings. Within the past few years the industry has had one-piece forged or extruded fittings offered to it to replace these expensive and makeshift arrangements. One-piece forged ells in standard sizes, tees of various run and outlet combinations, and one-piece dished "bull plugs" of essentially the same physical and chemical characteristics as the pipe, are now available with installed costs comparable to the handmade arrangements.

It is of interest to note that the friction loss at a forged elbow is 41.6% of that at a screwed elbow and only 19% of that through a mitered ell.

Forged steel flanges with extruded necks beveled for welding are now available in all sizes, weights and drillings. They may be welded directly into the line, their cost is comparable to the screwed type, and they have none of its disadvantages (liability to leak and fatigue failure) so their use is rapidly becoming universal.

Gate valves form a large part of the industry's investment. Almost all types are used in some form or another, but essentially all makes have the same general characteristics. The use of gray cast iron for the shell and bonnet, and in fact all principal parts, is almost universal. This is primarily due to cast iron's high resistance to oxidation, one of a pipe line's greatest hazards, whether buried or exposed. Valves must withstand extreme shock and tension and must meet internal as well as external corrosion. Valves are therefore improved mainly against oxidation on the outside, against corrosion and erosion on the inside and against high shock and strain.

Carbon content in cast irons for valve metals has been reduced to produce a finer grain structure. This does not materially reduce the metal's resistance to oxidation and greatly increases its resistance to tension and shock. Reduction of the carbon of course necessitates adjustment of the phosphorus, silicon and sulphur content.

Copper free "Ni-resist" cast iron, and nickel-copper combinations containing less nickel than "Ni-resist," have been developed that will increase the valve's resistance to oxidation and corrosion materially. Increased cost does not warrant their use except in rare instances, but research will no doubt develop a metal for the desired results without undue cost.

The problem of valve trim, mainly stems and seat rings, is considerably different. Failure of either interrupts the service, but the replacement cost is small. Conditions to be met are mainly corrosion from the fluid passing through the valve, resistance to abrasion and wear.

Seat rings may be closed over sand particles, scale or other solids. Material that will "squeeze" is ideal to produce tight closing valves, and bronzes have been most satisfactory. The life seems to depend upon accident — the closing of the valve upon some substance that would destroy the seat. Of course where valves are operated "pinched," erosion would be a factor, and where "sour" crudes containing hydrogen sulphide or other corrosive agents are handled, corrosion becomes a factor.

Manganese bronze stems give greatest satisfaction; a combination of wear, corrosion resistance and reasonable tensile strength is required. In the larger valves operating under high pressure, stronger steel stems are more desirable. The use of nickel steel or stainless steel is hardly warranted.

Diesel Engines

At intervals of perhaps 40 miles, depending on the terrain and the viscosity of the oil, are pumping stations that boost the oil along its way — "re-pressure" it, as we say. Such main line stations ordinarily consist of diesel engines and reciprocating

or centrifugal pumps. The operation and maintenance of this equipment is unique in that the load factor is usually much greater than for other service. Standby equipment for use during repairs is limited, and the locations of the stations are usually remote from machine shops or materials for repairs. It is therefore the policy to aim toward greater life of wearing parts, keeping in mind availability of materials in making any repairs, change in design or specifications of a given part.

Cylinder heads of diesel engines are often subjected to more severe service than in commercial practice. Conditions over which we have little control may necessitate protracted operation at high loads and excessive temperatures, or untreated cooling water may be used in an emergency resulting in excessive scaling and eventual breakage. It has been found that by making slight changes in the head design, satisfactory cast steel heads could be used with entire satisfaction. These heads also corrected weak elements of design in the original cast iron head.

Liners are generally made of a close grained, gray cast iron produced by an approved process with a maximum phosphorus content of approximately 0.35% and maximum sulphur content of 0.11%. The hardness ranges from 200 to 260 Brinell with the tendency toward the high side, keeping always in mind that they must be machinable. A honed finish is desirable. Replacements tend toward electric furnace iron; as centrifugal cast liners in the larger sizes are made more readily available, more of these will be used. A service life of 80,000 hr. is not unusual.

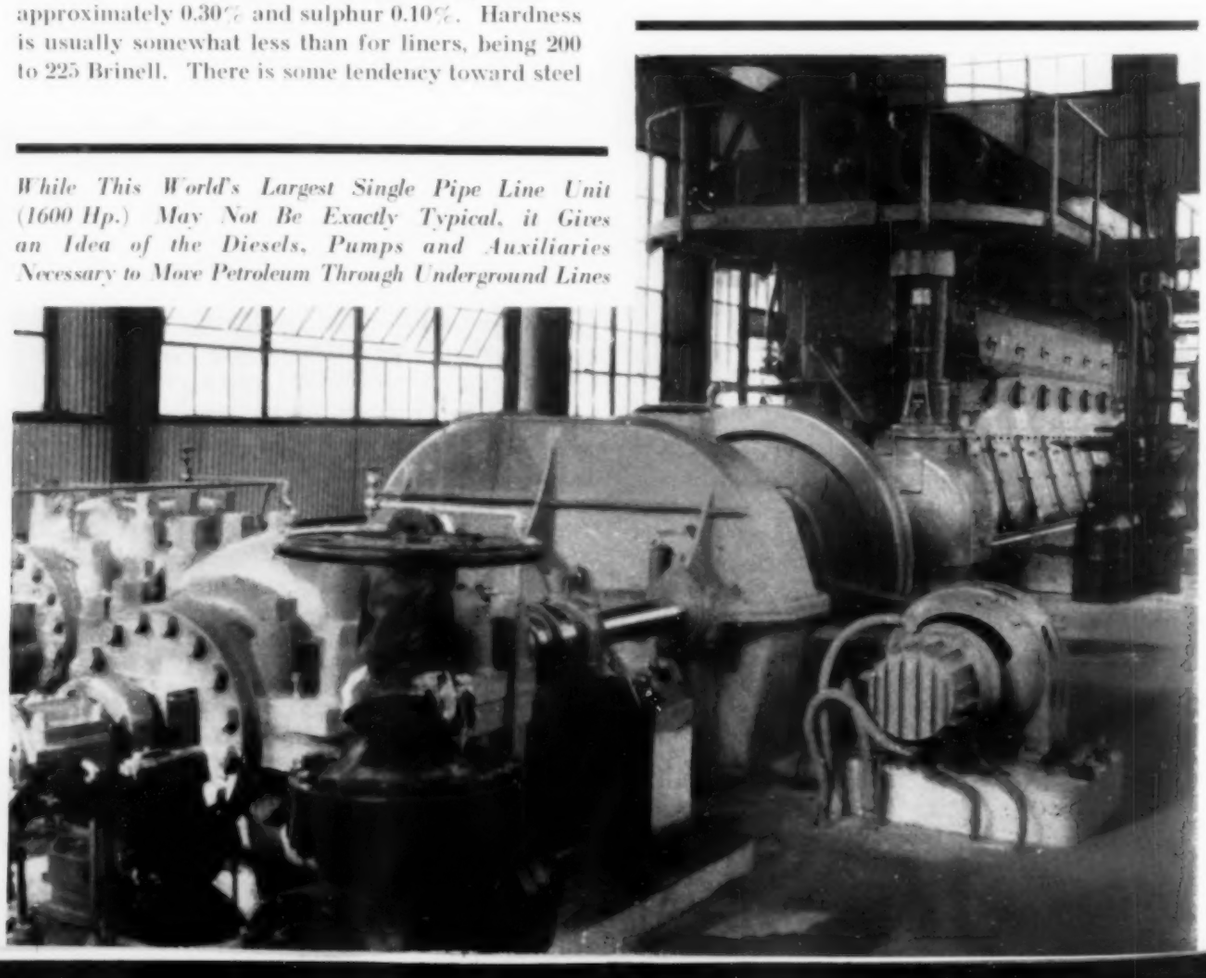
A "semi-steel" cast iron has been found most desirable for pistons. Maximum phosphorus is approximately 0.30% and sulphur 0.10%. Hardness is usually somewhat less than for liners, being 200 to 225 Brinell. There is some tendency toward steel heads in the larger sizes. Aluminum alloys have been unsatisfactory in this service.

Since crude oil from the line is used as fuel, and since this carries fine abrasive and is frequently corrosive, special attention is given to fuel systems.

Many manufacturers furnish hardened high carbon steel plungers as original equipment in their fuel pumps and these corrode seriously, resulting in failure of packing and excessive leakage. Various types of stainless steel were tried without material success due primarily to the inability to harden them sufficiently. A study of the physical characteristics of nitralloy "G" showed that it could be surface hardened to a high Brinell, leaving a ductile center. It was also found to be resistant to corrosion. Our first set of nitrided plungers have been in service 10,000 hr. without a single forced shutdown for repacking. From outward appearance, a life of at least 40,000 hr. is indicated. This compares with 500 to 10,000 hr. of service received from other materials tried.

Many of the engines in our service were originally equipped with fuel pump bodies of close grained cast iron, fitted with wing type valves of cold rolled steel. The chemical content of the crude oil used as fuel caused the edges of these valves as well as the seats to corrode rapidly. Valves made of tobin bronze and 18-8 stainless steel were tried. It was found that while the tobin bronze valves resisted corrosion better than the cold rolled steel, the 18-8 served from 20,000 to 30,000 hr. as compared to 3000 hr. obtained from the original metal. Under these conditions the difference in cost is, of course, negligible.

The valve seats, being machined in the fuel



While This World's Largest Single Pipe Line Unit (1600 Hp.) May Not Be Exactly Typical, it Gives an Idea of the Diesels, Pumps and Auxiliaries Necessary to Move Petroleum Through Underground Lines

pump body, were of cast iron and after approximately 15,000 hr. were so worn and corroded the entire fuel pump body had to be replaced at a cost of $40. To avoid this a boring machine was worked out to bore these bodies and press in a sleeve of 18-8 stainless steel to form the valve seats. Cost was $8, and the life was increased at least 50%.

Fuel injection nozzles in both solid and air injection engines are a constant source of trouble and the solution of these difficulties is by no means complete. Nickel cast steel injection needles have proven very satisfactory in several instances. Nitrided steels are not particularly effective as they do not permit sufficient regrinding, and the hardened surface fails from impact on the seat. Considerable success has been had with an all-stainless nozzle. Hardened parts are made of a 14% chromium steel with 0.30 to 0.40% carbon, and the non hardenable parts of an 18-8 with 0.10 to 0.20% carbon. They have already increased the service life approximately 400%.

Various springs always give trouble, particularly where sour crudes are in use. Much work is still to be done in this connection. At present there are under test springs of various heat treated carbon steels, stainless steel, and cadmium plated music wire. It is believed that stainless would prove best if it could be heat treated consistently. We can only urge that metallurgists apply themselves to this problem.

Positive Displacement Pumps

Large duplex and triplex, horizontal, double acting, reciprocating pumps are in most general use throughout the industry as re-pressuring units. The principal problems in their design reside in the fluid end. It must have strength and great fatigue resistance, as it is operated under relatively high pressures (and possibly under conditions of considerable shock) over a long period of time. The manufacturers have solved this problem through the use of a good grade of cast iron or forged steel.

A cast iron which has been found most satisfactory has the following composition: Silicon 1.5%, sulphur 0.1%, manganese 1.0%, phosphorus 0.17% and total carbon 2.5%. This metal will develop a tensile strength of 45,000 to 50,000 psi. It has a very high modulus of elasticity (25,000,000), and a high shock resistance and fatigue limit, yet is readily machinable. Such castings must be free from segregation or porosity in heavy sections, probably achieved by a narrow freezing range.

The much more expensive steel billet type of fluid end is machined from a solid carbon steel billet having the approximate analysis of S.A.E. 1030. The strength of a cylinder made of this material is in excess of any of the other parts of a pump, or of the pipe line. Its chief advantage is great resistance to shock.

The metal used for plungers should be hard enough to withstand the cutting action of the sand and scale in the oil, should have considerable resistance to corrosion, the ability to take a fine finish grind, and it should take on a glaze or polish in service. In general, the same metal used for cast fluid ends is furnished by the manufacturer for the plungers. Special service conditions may require the use of a somewhat higher carbon iron, a typical analysis of which would be: Silicon 1.25%, total carbon 3.10% and other elements as quoted above. When the abrasive materials carried in an oil are unusually high, considerable success has been obtained with a patented high carbon cast iron containing nickel. This material is quite ductile, has a fairly high Brinell hardness, and takes a very high glaze in service. The life of plungers has been increased approximately 300% through its use.

Frames of these pumps are of necessity rather complicated castings with corners, ribs, angles and reduced sections. To avoid possibility of cracks from cooling stresses, they are usually cast of a soft ductile iron having the following approximate composition: Silicon 2.4%, sulphur 0.07%, manganese 0.6%, phosphorus 0.3% and total carbon 3.5%. To prevent the frame from stretching when the pump is in operation, it is necessary to reinforce it with steel tie rods, pre-loaded, so the frame will always be under some compression.

Valves — The suction and discharge valves in the fluid end of these pumps form its "balance wheel." A good valve is quite often the difference between a good pump and a poor one. Valves are of the ball, disc, or wing guided type, in a wide variety of designs. The major factors to take into account in choosing one are strength, performance or pump efficiency, service life, economy of operation, and initial cost. Economy of operation depends, of course, upon how well the first three factors have been met.

A valve must be strong enough to withstand the pressures and shocks to which it is subjected. Correct ratios between seat area, lift and free flow must be adhered to, lest efficiency suffer. A valve may be strong and have a long service life, yet will be of little use if there is too much resistance to fluid flow, or too much slippage. Length of service is of importance because, aside from the expense of frequent replacement, shutdowns must be avoided. The first cost is, and should be, the least important factor. It is readily possible to spend several times the first cost of a good valve by purchasing several replacement sets of mediocre ones.

Due to the sand and scale which may be carried in crude oil the valves are subjected to excessive scoring action and abrasion. The view on page 610 shows two valve plates destroyed by scale, and some of the solids which did the damage. Where sweet crudes are handled, we have had considerable success with a fairly wide faced wing type valve of

manganese bronze of the following analysis: Copper 68%, zinc 22%, manganese 3%, aluminum 5% and iron 2%. Its tensile strength is approximately 100,000 psi. and its elongation is approximately 15% in 2 in. High strength, hardness, ductility and fair degree of corrosion resistance make this an eminently satisfactory material.

The width of face, necessary in anything except an extremely hard metal, leaves an appreciable unbalanced area, which means that to open such a valve against 750 or 800 lb. pressure, requires a momentary pressure considerably in excess of this in the chamber, and causes an undesirable valve pound. This same fault may be found with a ball valve, although of recent years there has appeared a hollow ball whose operation in this respect is much better. Ball valves in the sizes required are generally most unsatisfactory.

Valves faced with stellite have overcome many valve troubles, but their use has not yet become general.

The industry has had considerable success with this type of valve fitted with a flat faced Bakelite insert, with cap and guide made of S.A.E. 3115 or 3140 steel, heat treated to Brinell 350, working on a replaceable steel seat of S.A.E. 3115, 3110 or 4115, carburized and hardened to Brinell 600. This has the added advantage of considerably greater resistance to sour crude than most all-metal valves. Its action is very smooth, the wing guide may be designed to give any degree of rotation desired (a most desirable attribute which aids in keeping the seat clear and the wear minimized) and ample area can be allowed through the seat for fluid flow.

Bolts to adjust the wedges at crosshead and crank pin bearings were usually made of ordinary carbon steel. They are subject to extreme stresses in shear and in tension, especially if the bearing becomes slightly loose. Their life is increased from 2500 to 14,000 hr. by using S.A.E. 3140 steel.

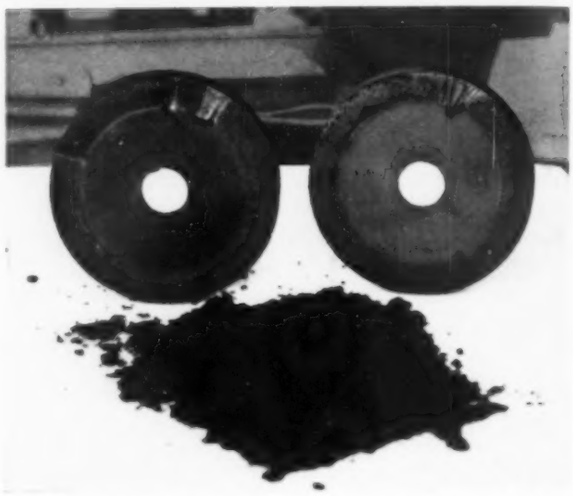
Pipe Line Centrifugal Pumps

The use of multi-stage centrifugal pumps for main line service is a recent development; in fact, they have only been in more or less general use in pipe lines since 1930. Originally they were the same as high pressure boiler feed pumps; however, pipe line service showed that many changes were necessary.

The casing must be machinable in fairly light sections and the diaphragms between stages must be rather thin to hold the length of the shaft to a minimum, and yet these diaphragms must be bored very accurately. A casing must be strong enough to be safe at a pressure of 800 to 1000 psi., and must be stiff enough to avoid deflections of appreciable magnitude. It must be dense enough to prevent any "sweating" between stages.

A very suitable iron for this service is as follows: Silicon 1.4%, sulphur 0.07%, manganese 1.0%, phosphorus 0.3% and total carbon 3.35%. Foundry problems, in so intricate a casting, are of primary importance as the metal must strip from the sand cleanly. The waterways must be smooth, as some of them are of such shape as to be reached with difficulty for hand smoothing.

Impellers are ordinarily cast of a leaded phosphor-bronze as this metal casts readily with a smooth surface, and it has high corrosion resistance. An approximate analysis would contain 75% of copper, 15% of lead and 10% of tin. These impellers usually carry replaceable steel wearing rings both at the eye and at the hub for increased wear resistance, and to renew the close running clearances when wear does occur.



Valve Plates Destroyed by Scale, and Some of the Abrasive Material Carried Through an Oil Line

Shafts and shaft sleeves present one of the most difficult problems encountered. Admittedly the method of installation and care of packing has a great deal more to do with the life of the shaft than does the material of which it is made. Some of the earlier pumps were not fitted with sleeves and wore excessively; repairs were made by replacing the shafts or designing sleeves to fit. Recently some success has been had with building up the eroded portions by welding with a carbon steel rod, producing a surface approximately 300 Brinell hard. This cannot be done more than twice, however, as the heat of welding changes the structure of the parent metal, and will induce failure.

Pumps of later design are fitted with shaft sleeves through the stuffing boxes. These sleeves must be hard to resist the wear caused by sandy oil and incorrectly adjusted packing. They should also be corrosion resisting. Nitrided nitralloy possesses the required hardness, *(Cont. on page 636)*

METAL PROGRESS JUNE, 1938; PAGE 611

Reference Shelf for Metallurgists

Suggested by Myron Weiss ⊜, Associate Editor of *Time* Newsmagazine

A well-rounded bibliography of useful professional books and journals to which a metallurgist should have access for general reference, supplemented of course by other texts of particular application to his own specialty

Encyclopedias, Handbooks, Directories

Directory of Engineering Alloys. American Society for Metals, 7016 Euclid Ave., Cleveland. 600 pages, 8100 commercial alloys ($10.00).

*__A.S.M. Metals Handbook.__ American Society for Metals, 7016 Euclid Ave., Cleveland. 1200 pages, products, processes, equipment and materials, statistics ($10.00).

Metal-Quarry Catalogs. McGraw-Hill Publishing Co., 330 West 42nd St., New York. 230 pages, lists manufacturers ($5.00).

Standard Metals Directory. Atlas Publishing Co., 150 Lafayette St., New York ($10.00).

Wire & Wire Products (Buyers' Guide & Year Book Issue). Quinn-Brown Publishing Co., 17 East 42nd St., New York ($5.00 yearly).

*__Iron and Steel__ (A Pocket Encyclopedia), by Hugh P. Tiemann, revised by G. A. Roush. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York. 589 pages ($4.00).

Chronology of Iron and Steel, compiled by Stephen L. Goodale, edited by J. Ramsey Speer. Published by Pittsburgh Iron & Steel Foundries Co., Pittsburgh. 294 pages ($5.00).

Cast Metals Handbook. American Foundrymen's Association, 222 West Adams St., Chicago. 424 pages, data for users of sand castings ($4.00).

Book of A.S.T.M. Standards. Part I—Metals. Issued triennially by American Society for Testing Materials, 260 South Broad St., Philadelphia. 898 pages ($7.50).

Abstract Journals (*Quotations are for yearly subscriptions*)

*__Journal__ of the Iron and Steel Institute. Section II. Notes on the progress of the iron and steel industries; an abstract journal. Iron and Steel Institute, London ($7.50).

*__Metallurgical Abstracts.__ Institute of Metals, London. Abstracts covering the non-ferrous metals. Available to members only; annual membership fee $15.00.

Metals and Alloys. Abstract Section. Reinhold Publishing Co., 330 West 42nd St., New York, ($3.00 yearly for complete magazine). There is a cumulative index to these metallurgical abstracts from 1932 to 1936 ($2.00).

Revue de Métallurgie. Abstract Section. 5 Cité Pigalle, Paris. Metallurgical abstracts (250 francs yearly for complete magazine).

Engineering Index. American Society of Mechanical Engineers, 29 West 39th St., New York. Covers engineering applications of metals and such allied fields as corrosion. Chiefly an index; the abstracts are little more than annotations. (Price varies according to the number of subdivisions desired.)

*__Chemical Abstracts.__ American Chemical Society, Columbus, Ohio. Covers the chemistry of metals fully ($12.00).

Geophysical Abstracts. United States Bureau of Mines, Department of the Interior, Washington, D.C. Abstracts of interest to miners and prospectors. Ceased publication in 1936.

British Chemical and Physiological Abstracts. Chemical Society, Burlington House, London. Performs the same office as does the American abstract journal ($30.00).

Mineralogical Magazine. Mineralogical Abstracts. Oxford University Press, London ($5.00).

Chimie et Industrie. Extraits de Chimie. Société de Chimie Industriel, Paris. Abstracts of commercial applications, including metal chemistry (500 francs yearly for complete magazine).

Société Chimique de France, Bulletin. Documentation. Société Chimique de France, Paris. Chemical abstracts of purely scientific nature, including those covering metallurgical chemistry (320 francs).

Chemisches Zentralblatt. Deutsche Chemisches Gesellschaft, Berlin. The German chemical abstracts. Covers metal chemistry as well as the other branches of the science (95 marks, subject to discount for foreign circulation).

Annual Survey of American Chemistry. National Research Council, Washington, D.C. Brief yearly reviews of chemistry, covering chemical aspects of metals as well as other phases of chemistry. Ceased publication in 1936.

Annual Reports on the Progress of Chemistry. Chemical Society, London. Yearly reports on pure chemistry ($3.50).

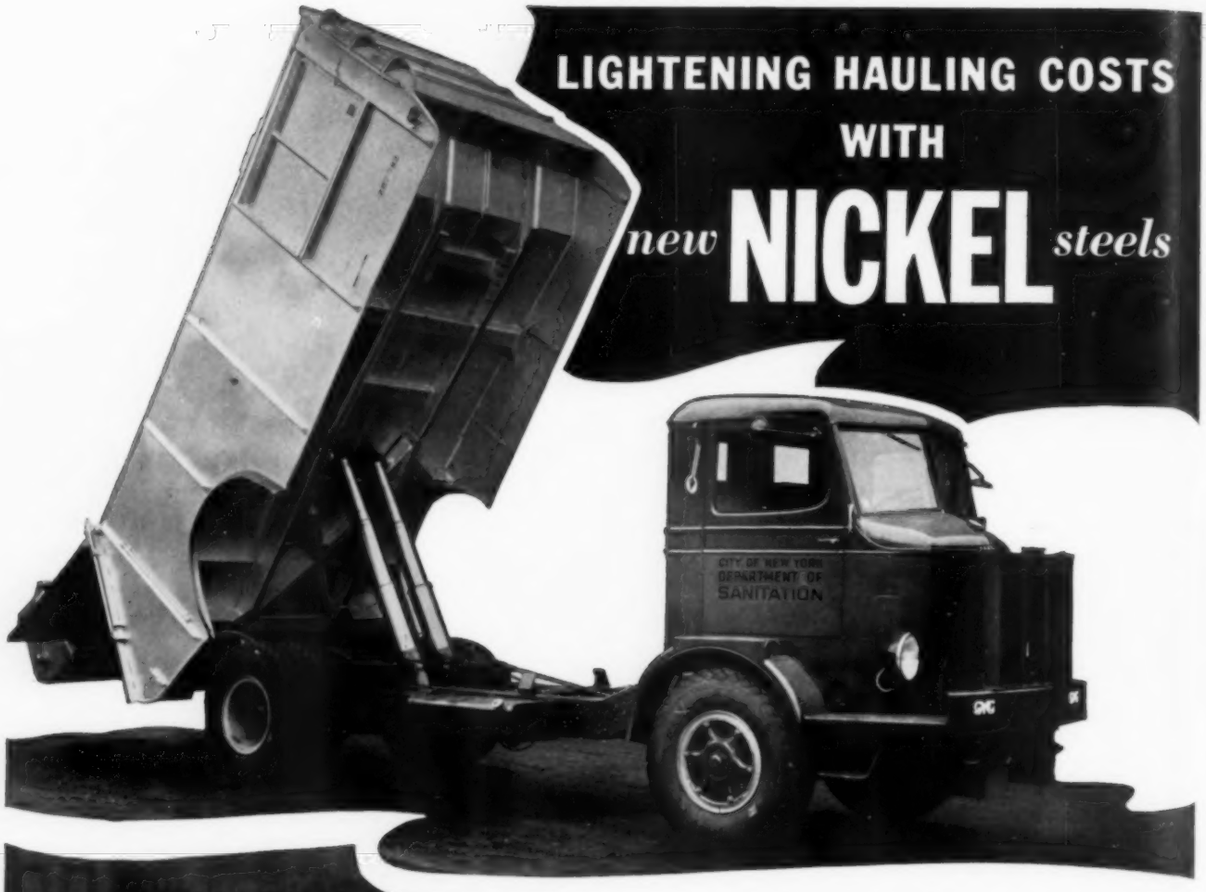
Report on the Progress of Applied Chemistry. Society of Chemical Industry, London. A yearly review of chemical industry ($3.50).

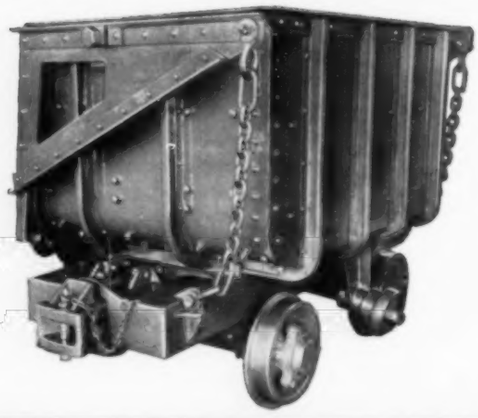
Industrial Arts Index. H. W. Wilson Co., New York. An index (not abstracts) of periodical literature of a less technical and more economic nature than those covered in other indices mentioned. Contains some material on metals (Price varies depending on number of periodicals subscribed to).

*These cover the literature best of all, and very efficiently.

JUNE, 1938; PAGE 611
METAL PROGRESS

LIGHTENING HAULING COSTS WITH *new* NICKEL *steels*





..ON MANHATTAN STREETS—To save trucking tons of deadweight through congested traffic, the City of New York specified its new fleet of refuse trucks with lightweight, high-strength bodies of "Yoloy". These self-loading, self-dumping bodies were built by Gar Wood Industries on GMC chassis. Yoloy is a Nickel-copper steel which resists wear and corrosion. It is produced by the Youngstown Sheet & Tube Co.

..OVER MOUNTAIN GRADES—The progressive Union Pacific Railroad has learned that freight car castings can be lightened 20-25% by utilizing Nickel cast steels. These tough Nickel alloy steel bolsters were produced by the Buckeye Steel Castings Company for the Union Pacific's modern new freight cars.

.DEEP IN MINES—3,000 feet down in a Copper Cliff mine, rust and corrosion continuously attack metals. Hurried loading and dumping of ore-bearing rock causes severe abrasion. To cut handling costs, light-weight Granby-type mine cars of Nickel alloy steels were ordered from the Canadian Car & Foundry Company. This modern Nickel alloy steel equipment so markedly reduced operating and repair costs that 123 additional cars will soon be in use.

THE INTERNATIONAL NICKEL COMPANY, INC., NEW YORK, N.Y.

Book Reviews

Structure and Properties of Carbon Steel

THE "REFERENCE SHELF" for metallurgists, suggested by Myron Weiss on page 611 may usefully be supplemented by a list called "The Condensed Library of Engineering," a minimum list of books representative of engineering and its basic sciences recently issued by Charles E. Lucke, professor of mechanical engineering in Columbia University, New York. However both of these lists reveal a lack of outstanding works on metallic materials of construction.

From books on Mr. Weiss' list may be found many answers to questions about commercial units in the metal industry. The very length of his list of abstract journals indicates the enormous flood of current periodical literature. Professor Lucke's list, on the other hand, is almost completely filled with texts on design and construction methods; aside from data secured in them or in various engineering handbooks, as listed, the designer must frequently be at a loss to know what may be expected of metals in current production and which of them are the best for the intended service, and the constructor equally uncertain as to their treatments and acceptance limits.

Basic literary work to supply this need is now being done by Alloys of Iron Research. Started eight years ago, and producing monographs at the rate of about one a year, several more years will be required to complete the original program — namely, to prepare a critical summary of the world's technical literature on iron and its alloys. Stupendous though this program is, it is being gradually accomplished. and in the not-distant future we will have a shelf of books that will give the answer to a multitude of questions about these most important alloys. Possibly Frank Sisco, the editor of the series, may then find time to distill from his volumes enough for a single text for civil, mechanical, electrical and the other engineers, telling them what they ought to know about irons and steels in order to use them to the best advantage. Then he can turn his attention to non-ferrous alloys.

Thus with Mr. Sisco's future properly arranged for (without his knowledge and consent!) one can turn to some comment on the monographs on the Alloys of Iron and Carbon, published in two volumes during 1937. These occupy the middle ground between the work on The Metal Iron by H. E. Cleaves and J. G. Thompson, published in 1935, and a projected one on Cast Iron. Even in this middle field the available information is so vast that a prime subdivision had to be made: Volume I is on the Constitution of the Alloys of Iron and Carbon, and was written by Samuel Epstein; Volume II is on properties, and was re-written by Frank T. Sisco from a preliminary manuscript prepared during 1931 to 1934 by the staff of Battelle Memorial Institute.

From the thousands of existing publications, some 675 are listed by Mr. Epstein as containing reliable information on the structure of the alloys and the way such structure can be modified. Mr. Sisco finds an even larger number (822) worthy of citation as containing experiments more particularly on the mechanical properties, and how these may be changed to increase the utility of the steel. On account of this very mass of information a new method had to be used by the authors; instead of attempting to correlate the published work on, say, the influence of carbon content on the properties of cold-drawn seamless tubes, the work of a single author — chosen as best and most comprehensive — was selected and summarized. This was judged necessary other than as a time and space saving matter, because so

many unknown and undefined variables exist in the history of the specimens that the work of two experimenters is likely to show fairly wide divergencies in specific results, yet the clear indications of *trends* may agree closely.

Perhaps it is this freer method of treatment that makes these last two volumes read more easily than the previous ones. Perhaps it is rather that the quality of the books, high from the first, is constantly increasing. At any rate they are more than mere masterpieces of condensation; they are pilot's-eye views of the most important area of knowledge about materials —and it is a view as it exists today, not 20 or even 10 years ago. E. E. THUM

Etching Agents

Reactifs d'Attaque Metallographique, by Albert Portevin and Paul Bastien. 267 pages, 5½x8½ in. H. Dunod, 92 Rue Bonaparte, Paris (6e), France. Price 105 fr.

By far the most important manual on the subject of metallographic etching yet to be published is this book which describes 204 etching reagents and methods, many of these having been developed since the publication of Berglund's "Handbook of Etching" in 1929.

The first chapter gives a general consideration of the subject of etching and is followed by chapters classifying the reagents for ferrous alloys and various groups of non-ferrous alloys. Some idea of the comprehensiveness of the volume may be had from the fact that 5½ pages are devoted to picric acid. Included are various recommended compositions, applications of the reagent to iron and mild steel, to unhardened steels, to heat treated steels, low alloy steels, and cast iron. Graphs and tables are used to indicate the length of attack for various solution strengths, temperatures, carbon contents, and for distinguishing pearlite, sorbite, troostite and martensite. Graphs, tables and diagrams are used wherever possible to simplify and clarify the methods and results.

Necessarily much information is reprinted from other readily available sources; other material has been secured from comparatively obscure places. For instance, the section on identification of inclusions in iron and steel contains a modification of Campbell's well-known diagram (Metals Handbook, 1936, p. 561, and METAL PROGRESS, October 1937, page 434) as well as a table listing 23 types of inclusions, their normal appearance, and appearance under polarized light and when etched by ten different reagents.

Appendices include a discussion of the electrographic method of Glazunov and Krivohlavy, an explanation of quantitative micrography, and a brief consideration of grain size measurement. Not the least feature of the book is a set of three indices, the first classifying the alloys by composition or surface appearance, the second classifying the reagents by name, composition and effect, and the third listing the names of originators of etching solutions and authors of the literature references contained in the text.

Metallography

METALLOGRAPHY, by Cecil H. Desch. Fourth Edition, 402 pages, 5½x8½ in., 147 text figures and 18 plates. Longmans, Green & Co., London and New York. Price $8.00.

Resetting to a longer type line and printing on a larger page enables the third edition to be expanded 30% in content without increasing the number of pages. Unfortunately, the longer line, closer spaced, is considerably less legible. Unfortunately, also the price is so high as to restrict sale, and apparently unjustifiably so, for the jacket printed in England bears the price 21 shillings net, which, figured to dollars and 15% import duty added, comes to $6.00. Why the $2.00 surcharge for the opulent Americans?

The field of metallography, as bounded by the limits of this book, comprises a study of the *structure* of metals and alloys, structure as it is affected by composition, temperature, and work, hot or cold. Of this broad field, Dr. Desch's treatment is general, rather than specific. In other words, such subjects as the solidification of eutectics and their various aspects under the microscope are described in detail; that being done for eutectics in general, specific appearances such as pearlite may be dismissed briefly. In fact, the metallography of iron and steel is summarized in the next to last chapter of 24 pages; the enormous field of non-ferrous alloys is compressed into the final chapter of 11 pages.

Whether it is a general pedagogical principle, or only a mental limitation of the reviewer, it seems easier to go from the specific to the general, than in the opposite direction. Consequently, one would judge that the beginner would find this book a difficult one to use. On

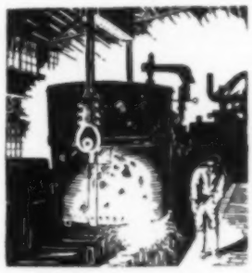
the other hand, the more advanced worker will prize it as a summary of recent thought on all phases of general metallography, and, in the event he wishes to study the evidence supporting a given view, as a bibliography to important current literature. This mode of presentation ("correlated abstracts" is Dr. Gillett's term) also submerges the author's own style, and frequently conceals his own judgment as to the correct interpretation of conflicting evidence. It is evident, therefore, that Desch's Metallography is a place where the expert in brass, for instance, can readily find out how his specialty fits into the broad map of the metallurgical art and science.

Comparison with the third edition, printed 15 years ago, indicates those lines where the greatest activity has been. Chapters on phase rule, construction of equilibrium diagrams, thermal analysis, are relatively unchanged. Other sections on solidification of ingots, X-ray crystal analysis, corrosion, plastic deformation of single crystals, structure of cold-worked metal, fatigue failure, transformation in solid state (age hardening) are either new or rewritten and expanded. The book therefore becomes a notable addition to the library of metallurgists who must keep up to date.

Alloy Steel

VANADIUM STEELS AND IRONS. 189 pages, 6x9 in., 72 figures, 60 tables. Published by Vanadium Corp. of America, 420 Lexington Ave., New York. Price $1.25 (free to executives and engineers).

Although it may sound like a carping criticism, this book would be considerably improved by a title page, setting forth the name of the author, editor, or responsible producer. It would not detract from the value of such an excellent summary as this to state at the very outset that the book is a compilation of published information from a number of sources, including the wide experience and laboratory investigations of the chief vanadium producer. In fact, the technical capabilities of men in this staff are so well known that should one of them be named as author or editor it would immediately lend authority to the volume.



The book is a dictionary of facts rather than a text. It properly starts with an exposition of the effect of a modicum of alloying vanadium on the grain size control of steels and the solubility of carbides at various temperatures (or, to speak in everyday language, its effect on the hardenability and the tempering of steel). One might hope that in subsequent editions this introductory chapter could be considerably expanded; in its present shape it is so closely written and assumes such a good background of recent metallographical theory and terminology that it is likely to be obscure to any but the advanced student or specialist. Nevertheless, such a statement of metallurgical fundamentals at the very outset of the book is necessary to correlate the large mass of detailed information on specific alloy which is presented in later pages.

A noteworthy restraint is observable throughout the book, refreshing to observe in a promotional publication. More or less vanadium may be added to *any* plain or alloy steel (and probably, on occasion, has), but that does not make them all commercial analyses. In comparison with the multitude of possibilities, a relatively few applications have stood out for many years and represent steels where vanadium, either alone or in conjunction with other alloys, enables the steel maker to produce materials consistently of a measurably higher grade and the steel user to induce in it properties of toughness, strength and fatigue resistance more readily and economically than by other means. In addition to these old and well-established uses, some newer ones are described and a statement of the properties responsible therefor, such as plate and castings for sub-zero service, steels for nitriding, welding rods, and the simultaneous large increase of carbon and vanadium in several recent varieties of toolsteel.

No less than 21 "S.A.E. charts" of an equal number of vanadium steels are included, many of them never before published. A notable feature of these is that they show the properties of the normalized and normalized-and-annealed steels as well as the normalized-and-quenched samples drawn at various temperatures. The test results given for the low draws are for heat treated ½-in. pieces and the high draws are for heat treated 1-in. pieces, thus conforming to usual practice with light pieces and with heavy plate, forgings or castings.

Brief Notes on New Books

Aluminum. Douglas B. Hobbs of the publicity staff, Aluminum Co. of America, has written a book on "Aluminum, Its History, Metallurgy, and Uses, With Projects for the School and Home Shop" (Bruce Publishing Co., Milwaukee, $3). Skipping over the popular presentation of the technology — a difficult class of writing, in this case well done — one is arrested by the "projects" and almost impelled to rush out and buy a set of metal working tools to add to the gimlet, saw, hammer and monkey wrench on the cellar work bench! Aided by Messrs. Stipek, Salisbury and Strattard (who, one suspects, are currently executing new designs for the beautiful Kensington ware) the author describes 25 projects ranging in difficulty from an ash tray to a coffee table. Aluminum is not yet common enough to be bought in the neighborhood lumber yard or corner drug store, so the Aluminum Co. of America has packaged the bill of material for each project, and the necessary metal can be secured through any of its sales offices.

Non-Ferrous Alloys. It is well known that the stress-strain curves of many alloys are a straight line for low loads but quickly start to curve away. Recorded values of the proportional limit, elastic limit (load for permanent set), Young's modulus, and proof stress will therefore depend upon the accuracy of the testing equipment, particularly the extensometer used to determine the deviation under load.

Judged by this criterion, the reliable data are contained in a relatively few publications during the last decade. J. McKeoun and E. D. Ward have made such an appraisal and have presented their findings on copper, nickel, aluminum, magnesium and their common alloys in Research Report No. 59 of the British Non-Ferrous Metals Research Association (price 6 shillings). The page size, 12x10 in., is convenient for the tabulations, but almost impossible to house in more-or-less standardized book-cases.

Refractories. The second edition of Modern Refractory Practice by Harbison-Walker Refractories Co. is more than a deluxe enlargement of the pamphlets issued to mason foremen to show them what shapes and sizes are made in various firebricks, and give them tables so they can order the necessary ones for an arch of given dimensions without the painful labor of thought. Printed by the Caxton Co. of Cleveland and priced at $2.50, it is, in fact, beyond criticism as a specimen of the bookmaker's art. Valuable contents to an engineer are the series of perspective cross-sections of modern melting and heating furnaces, showing details of the refractory construction; another section deals with correct methods of bonding, expansion jointing, floor construction and roof suspension. Thirty pages are devoted to a useful glossary of terms, trade and scientific, and a description of the properties of refractories, including those new ones with high alumina or high magnesia.

Metallography in Color. Now that plain, monochrome "stills" in microscopic metallurgy have been supplemented by movies of such things as the austenite → martensite transformation, it is to be expected that color photography will follow the styles in outdoor kodakery. To such enthusiasts a 56-page brochure entitled La Métallographie en Couleurs by Joseph Malette will be welcomed. (Published by H. Dunod, 92 Rue Bonaparte, Paris, France, at 38 francs, plus 10% postage.) About 18 pages is devoted to the etching of a polished steel specimen so that the various metallic constituents will stand forth in contrasting colors, and to the reproduction of these appearances photographically. Some of the results at 200 diameters after etching up to 100 min. are reproduced in four-color halftones. Although the printer may be much to blame, it hardly seems that they are worth the trouble; a more intelligible picture could be secured by less tedious methods. The author (who is honorary head of the chemical laboratories in the National College of Roads and Bridges) may also be suspected of being more receptive to new ideas in photography than in metallurgy, for his iron-carbon equilibrium diagram shows beta iron but no delta, and defines the constituents in steel (including "osmondite" and "hardenite") with the phraseology adopted in 1912 by the International Association for Testing Materials.

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"SUPPOSE I get sick? After all, I'm only human. And if I do get a touch of colic . . . or have a nervous breakdown . . . do you know what'll bring it on? Worry! Yes, sir, worrying about how long it would take us to get the doctor if anything should happen.

"Or suppose a pipe bursts in the bathroom? Or a burglar comes along? When something like that happens you don't write a letter, or go after help on horseback. No, sir. You hop to a telephone!

"And what about my mother? She's got marketing to do. Sometimes she needs to get in touch with Dad during the day. And there are errands to be run. Well, she can't do all those things without a telephone . . . and at the same time give me the attention I expect.

"All Dad needs to do to have a telephone is get in touch with the Business Office. I'd do it myself if I could just get out. But I can't. So is it any wonder that worry is keeping me awake half the day?"

BELL TELEPHONE SYSTEM

Personals

Fred D. Hamilton has been made manager of sales, sheet and strip division, Buffalo District, Brace-Mueller-Huntley, Inc.

Glenn Thiersch, sales engineer for E. F. Houghton, has been transferred to Peoria, Ill.

With Eastman Kodak Co., in charge of metals section, material standards department: **F. G. Jenkins**, formerly assistant materials engineer, Fore River Plant, Bethlehem Shipbuilding Corp.

Frank A. Shute, formerly casting sales engineer, Farrel-Birmingham Co., Inc., has joined A. F. Holden Co. in charge of commercial heat treatment sales in southern New England.

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Robert H. Leach, manager of the Bridgeport plant and director of research for Handy & Harman, has been made vice-president in charge of production and research. **John L. Christie**, formerly chief metallurgist for Bridgeport Brass Co., has joined Handy & Harman as assistant to Mr. Leach.

Transferred: **Truman S. Fuller**, from metallurgist, research laboratory, General Electric Co., to engineer of materials, Schenectady Works Laboratory.

Edward J. P. Fisher has resigned his position as metallurgical engineer with Republic Steel Corp. in Chicago to do consulting work.

Elected to honorary membership in the American Institute of Mining and Metallurgical Engineers: **Albert M. Portevin**, regular correspondent to **Metal Progress**, and a leader in French technical advance.

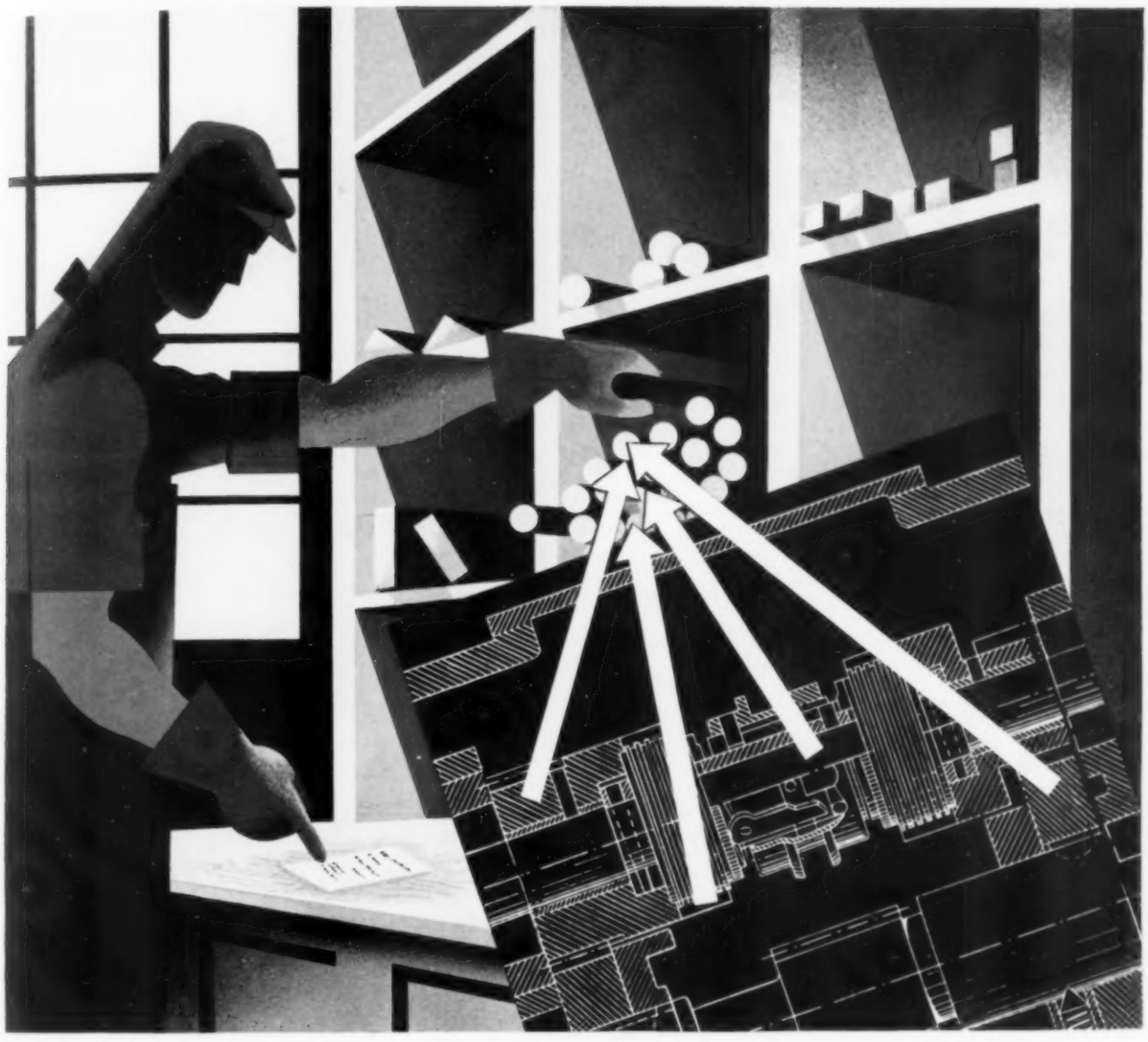
Transferred by Climax Molybdenum Co.: **Telfer E. Norman**, from Detroit laboratory to test metallurgist at the mine and concentrator, Climax, Colo.

Bernard J. Baecher, formerly junior metallurgist at National Bureau of Standards, is now junior materials engineer, New York Navy Yard.

George H. Hendricks has been promoted from assistant foreman of the heat treating department, Tractor Works, International Harvester Co., to plant metallurgist, East Moline Works.

R. L. Schell has resigned as chief melter with National Malleable and Steel Castings Co., Sharon Works, to return to Edgewater Steel Co. as open-hearth superintendent.

C. J. Gregg has been transferred from the metallurgical staff of the New Kensington Works of Aluminum Co. of America to the Alcoa Works.



MANY PARTS...ONE STEEL

SPECIALIZATION has its spheres, but in a manufacturing material ***versatility*** usually has the advantage. For instance, a truly versatile steel—one that can be made to meet the individual requirements of different applications—offers economies and shop efficiencies obviously impossible with a multiplicity of types.

One company building machine-shop equipment has standardized on a Chrome-Manganese-Moly steel for a great variety of parts. It was selected because it can be heat treated to a high hardness and still remain readily machinable.

Versatility is a feature of Moly steels in general. It reduces the chances of error by simplifying stockroom procedure and inventories; permits greater standardization of processes; assures more uniform results; and is an important factor toward economy.

The wide range of applications of Moly steels has been definitely proved in laboratory, shop and field. Our book, "Molybdenum in Steel," offers a quick technical survey of their scope. We invite engineers and production executives to write for it. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

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Climax Mo-lyb-den-um Company

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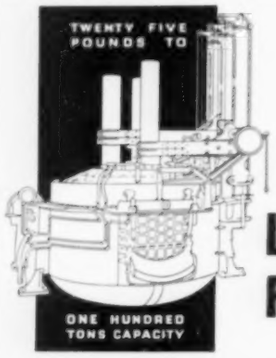

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Mechanism of Fatigue Failure

By H. J. Gough

Extracts from 1937 Report of National Physical Laboratory (England)

Researches with the aid of a precise X-ray diffraction camera into the change of the crystalline structure of a normalized mild steel as it approaches failure under stress have already been published. [See, for instance, the abstract in Metal Progress, Sept. 1937, page 276.] A progressive deterioration of the structure was found, fracture being associated with breakdown — partial or complete — to a limiting size of crystallite of dimensions between 10^{-4} and 10^{-5} cm. It was conjectured that a condition of marked lattice distortion was also an essential condition of fracture, and it was considered that further light would be thrown on the problem by an investigation of similar material, but commencing with a structure which had already been brought to a fragmented condition by cold rolling.

A further supply of the steel in bar form was therefore cold rolled to 49% of its original area; in this condition the X-ray photogram of the material shows a diffuse diffraction ring, indicating complete fragmentation without any evidence of preferred orientation. Using an improved technique so that a specimen was always photographed at exactly the same point on its surface, a study has been made of the progressive changes in structure caused by the application of static stresses, also of cycles of reversed direct stresses (tension and compression) above, at, and below the safe fatigue range.

Results have clearly revealed certain fundamental facts: The process of grain fragmentation resulting from any stress system must, in itself, be regarded as a compensating effect which first enables the structure to resist or retard further change. The modified structure is in a stable state under the externally applied

(Continued on page 622)

YOUNGSTOWN ALLOYS CARRY THE LOAD WHEN DRAWBAR BUCKS HORSEPOWER . . .

The steady pull of this streamlined Oliver Row Crop "70" tractor is fought, every inch, by the kicking, bucking drag of farm machinery.

That fluctuating stress lands full force on transmission gears and rear axle, so the Oliver Farm Equipment Company use Youngstown Alloys for this difficult assignment.

Increasing use of Youngstown Alloys for the tougher jobs is a direct result of the care we insist on in the manufacturing process, resulting in uniformly high quality, uniformly consistent.

Use Youngstown Alloys and you, too, will find your sales and profits increase--because of fewer rejects, and a product that stands up in service.

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Manufacturers of Carbon and Alloy Steels

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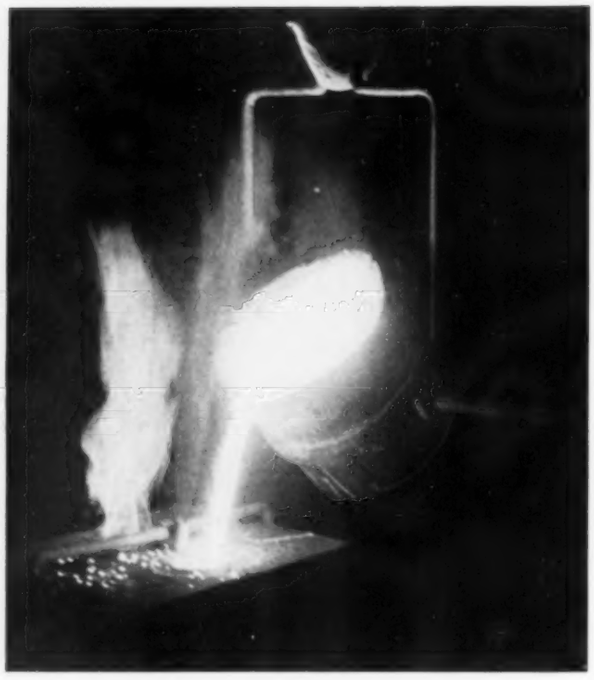
4-2A

ALLOY YOUNGSTOWN STEELS

YOUNGSTOWN

So we poured our 16,000,000th lb. . . .



SEVERAL weeks ago, according to our foundry records, we poured our sixteen millionth pound of NICHROME* for heat-resistant and corrosion-resistant castings. This in addition to ingots for rolling and drawing into NICHROME wire.

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There was no special ceremony. No extra thrill. No unusual occasion. For, week by week during almost a quarter century, the Driver-Harris foundry has been pouring many tons of D-H alloys for castings and ingots. It's all in the day's work.

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But if such outstanding experience means anything to you — and likewise unparalleled facilities ranging from drafting board and pattern shop to finished casting and machining — just turn that severe-service casting problem over to

DRIVER-HARRIS COMPANY
HARRISON, N. J.

Chicago Detroit England France
Cleveland *Reg. U.S. Pat. Off. Italy

NICHROME

Fatigue Failure

(Continued from page 620)

stressing system; in this manner the well-known increase of hardness and strength is conferred by cold work.

The effect of later and further deformation or fatigue stressing on such fully fragmented material is to induce a state of lattice distortion within the crystallites. Apparently there is a limit to the amount of such distortion; when this limit is reached, the material fractures, either completely, as in the case of static stresses, or locally by the action of progressive cracks under fatigue stresses.

Two examples from the fatigue study may be quoted:

Under a safe range of reversed stress no change was observed in the diffuse diffraction ring initially obtained from the cold rolled metal, but under an unsafe range of stress, with increasing cycles, a progressive drop occurred in the intensity of the ring relative to the background, a reduction of as much as 86% being recorded at fracture. Apart from this drop, no other changes occurred in the diffraction ring. There was no radial diffusion, such as would be associated with further break-up of the crystallites, nor any departure from the original uniform distribution of intensity around the circumference, such as would accompany preferred orientation.

Thus the observed effect is only to be accounted for by the incidence of intense lattice distortion in the crystallites, characterized by a staggering of the atoms about their normal positions and a consequent flattening out of the electronic distribution between the atomic planes.

Whitey Sez:

"The best way to get good service is to give it . . . Teamwork and routing efficiency in our office, coupled with an amazingly complete stock of electrodes in all sizes and analyses, put your order in transit the hour it is received."

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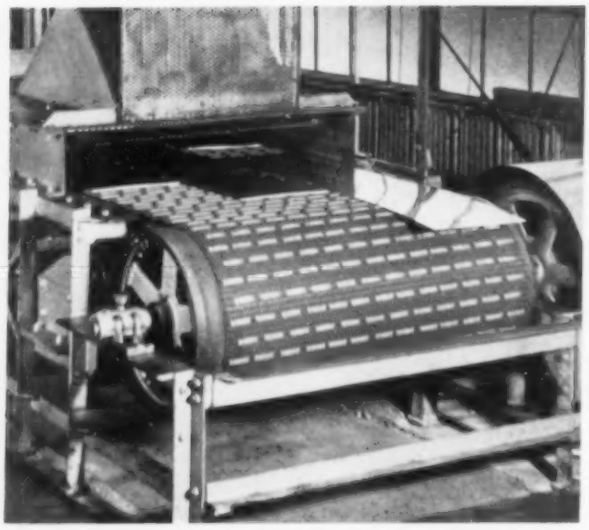


Double Profit

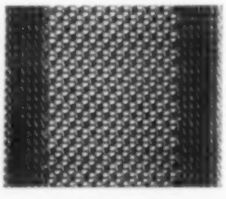
"Cambriloy" Mesh Belts

for Annealing Rolled Aluminum Sheets

The photograph shows a "Cambriloy" mesh belt in operation on a W. S. Rockwell Company furnace. The use of this belt has resulted in quality of product and economy in production. Aluminum cleats prevent the product from contacting the wires of the belt—any marking is prevented.

Real economies are effected. An exclusive Cambridge feature — the Duplex Selvage gives double strength at the belt's high wear point guaranteeing extra hours of service, operating efficiency. Open mesh construction provides low thermal capacity, which means fuel economy, permits even heat circulation.

The Cambridge engineer in your territory can help you plan an economical annealing process set-up. Consult him.



Section of "Cambriloy" Mesh Belt showing money-saving Duplex Selvage which guarantees double wear.

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Toolsteels

(Continued from page 605) unusual detected in the other more simple acceptance tests.

No doubt any reader would be well repaid if I would now put down some formulas and recipes for the right steels for the jobs that come up from day to day in the toolroom or engineering department. Unfortunately this is not possible. The information on toolsteels as supplied in the makers' catalogues must be very general in nature, and this is also necessary in the specifications quoted in this article, so that instead of the nice little "cook book" we have to rely on our own or others' experience. To build up this experience is a very important part of the metallurgist's job.

The one right way to do it is to collect and keep on file performance records of specific tools, as well as a complete history of the material they are made of and their treatment as they were made up. In this way, over a period of time, concrete information of the most valuable kind will be available and we can make up our own little book of experience. I believe this is the only way we can take ourselves and our plant out of the rule of thumb and opinions class and make real progress in tool engineering.

Finally a word is in order about defective tools that are defective through no fault of the steel. Too often the toolroom is inadequately equipped with furnaces, quenching facilities and circulating and cooling equipment. We should also have adequate drawing or tempering facilities. With almost no exception tools should be drawn after hardening, either for relief of hardening strains, or to relieve the hardness somewhat and gain toughness. There is little justification of the older methods of reheating tools before the open door of a furnace, on a hot plate or with a torch flame. The drawing should be done in a definite equipment for the purpose, either of the oil or salt bath type or in some of the modern convection heaters (air drawing furnaces).

Finally, many a good tool has been spoiled in grinding. Especial care is necessary with tools overheated in hardening, or steels that are coarse grained at proper hardening temperatures. Such tools will resist grinding cracks better after a high draw.

MISCO CYANIDE LEAD and SALT POTS

Misco pots are cast of the correct alloy for the type of service intended

MISCO pots are long life pots. This is proven by service records up to 20,000 hours . . . That is why more than 100 users of pot furnaces specify Misco lead, cyanide, and salt pots exclusively . . . Misco pots are sound and correctly proportioned to achieve maximum operating efficiency. Misco has many standard designs and more than 200 stock sizes. Designs for special requirements will be furnished gladly. Misco's experience in producing thousands of lead, cyanide, and salt pots is at your disposal.

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A dependable source of supply for Furnace parts, Chain, Roller rails, Furnace conveyor rolls, Trays, Carburizing and annealing boxes, Retorts, Lead and cyanide pots, Dipping baskets.

Who's Who in This Issue

Samuel C. Spalding got into metallurgy by way of the heat treat at Remington Arms in Bridgeport immediately after his graduation from Columbia as Mechanical Engineer in 1915. After the War he became metallurgist for Halcomb Steel Co. of Syracuse, being chairman of that chapter in due time, and becoming known to other chapters by his common sense talks about toolsteels and steel tools. In 1930 he joined the staff of American Brass Co., moving to Waterbury. New Haven Chapter promptly elected him chairman and he was Trustee of the national society 1935-1937.

When looking for a reporter for the openhearth meeting, the editor turned to the obliging Republic organization and Earle Smith assigned **Irving A. Oehler,** openhearth metallurgist at the Donner plant to the job. Oehler is a comparative youngster, having received his doctorate in metallurgy from Rensselaer Polytechnic Institute in 1935. His undergraduate department was electrical engineering; doubtless the metallurgical slant was emphasized by Professor Hunter.

Another of the juniors is **Howard A. Smith,** who is now in charge of stainless developments in Republic Steel's metallurgical laboratory at Massillon. His interest in stainless began in 1935, when for two years he was a research associate at Massachusetts Institute of Technology in the broad investigation started by The Chemical Foundation into the causes and cures of pit corrosion. Ph.D. in physical chemistry from Illinois in 1931, he was with A. O. Smith in Milwaukee for a time, and then, from 1933 to 1935, held a fellowship from National Research Council at Metals Research Laboratory, Carnegie Institute of Technology.

According to his own admission, **Van Fisher** liked photography better than Ohio State, so he endured only one year of it and then sold cameras at Gimbels, New York, until the depression swept him back into college, this time at Wisconsin. Portraiture paid the way. His first pictorial story was a series about rats in the experimental laboratory of Dr. Harry Steenbock, who used them in proving the existence of vitamin D. Shortly after arriving in Cleveland in 1935, these rat pictures sold the idea that a technical story could be told largely in photographs with a minimum of text, and since then his stories have appeared in **Metal Progress** at frequent intervals. In 1937 he symbolized in pictures the whole complex story of how the Buick automobile is made, spending a week on the scenario, taking over 2000 negatives and falling 30 ft. through one of the shop roofs at Flint before it was finished.

(P.S. One of his photographs has just taken first prize at the May show at the Cleveland Art Museum.)

Lewis F. Scherer graduated a B.S. in Mechanical Engineering at Illinois in 1925 (with two letters for football) and immediately was hired by Fairbanks, Morse and Co. For three years he was occupied mostly in its experimental and development division, so he came to the Texas Pipe Line Co. with a background of information on how to make good machinery better. In nine years he has seen many developments connected with the expansion of the Texas company's mileage from 5100 to 8400 miles. His article on page 606 is an evidence of the keen interest in quality metals shown by leading men throughout the entire petroleum industry.

Irving A. Oehler

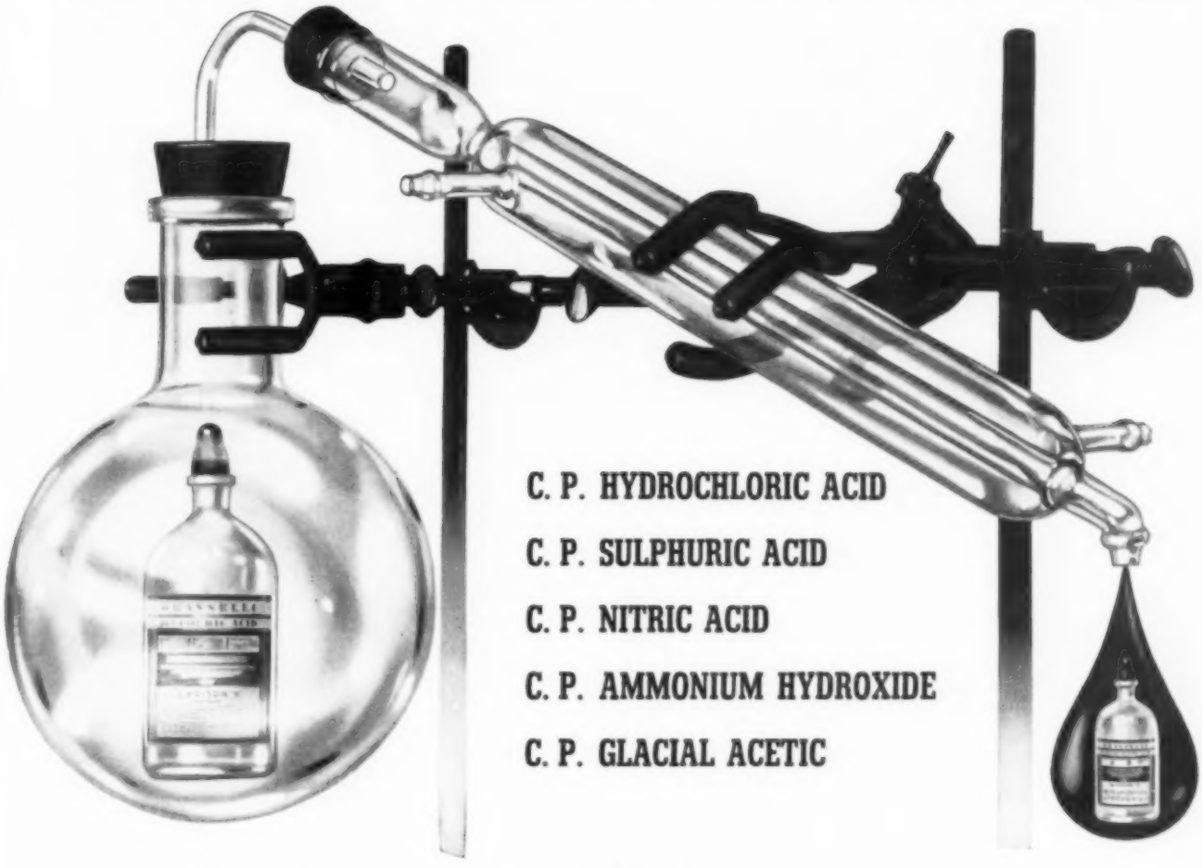
Samuel C. Spalding

Van Fisher

Lewis F. Scherer

Howard A. Smith

THERE'S PURITY IN EVERY DROP



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Cyanide Mixtures	Pressed Steel Pots
Neutral Salt Baths	Furnace Cements
Metal Cleaners	Carbon Preventer

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DETROIT

Oil Lines

(Continued from page 610) but its case is quite thin and it has little resistance to corrosion. A carbon steel with a deep carburized case is ideal for wear resistance, but rusts easily. If it were not for the poor hardenability of the so-called "hardenable stainless steels" they would be ideal in all respects. Stellite has been used with some success, but it is a very poor bearing material, and gives packing trouble. Much experimentation is still being done on this problem of suitable material for shaft sleeves; its importance cannot be minimized. One interesting trial is being conducted with a high chromium steel, centrifugally cast and hardened after machining.

Shafts were originally made of a carbon steel, but present practice calls for a shaft of highly alloyed and thoroughly normalized steel. The long span between bearings, weight of the rotating parts, and the high speed, all combine to make this most important.

Water Coolers. It has become quite common practice to use shell and tube type heat exchangers for cooling the water from engine jackets. These exchangers utilize the relatively cool stream of oil handled by the main line pump, the oil passing through the tubes and the water through the shell.

Water systems of this type are generally "closed," with a vent to atmosphere. It is well known that dissolved oxygen in water attacks iron to form ferrous hydroxide. The initial attack may be due to pure chemical action, or to small galvanic currents caused by variation in the microstructure. Once started, there is a definite local galvanic action which causes pitting. This action may be controlled by keeping the water alkaline by chemical treatment, and adding sodium sulphite to react with the dissolved oxygen to form sodium sulphate.

This treatment is effective so far as the heavy castings and piping are concerned, but is not always effective in protecting the thin tubes of the exchangers. It was first thought that most of the trouble would come from the oil side; however, quite the contrary was true. When leaky exchangers were retubed with admiralty metal it was soon found that dezincification had to be considered.

It is generally understood that a brass of approximately 85% copper, 15% zinc offers the greatest resistance to corrosion by water, and new exchangers for pipe line work are now generally specified to be tubed with such a brass. High hopes are held for their success. When it is realized that one pipe line company alone operates over 75,000 sq.ft. of shell and tube exchangers, the importance of protecting this investment becomes obvious.